REPORT RESUMES

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THE JOB PERFORMANCE OF SCHOOL ADMINISTRATORS--A RESEARCH DEVELOPMENT PROJECT.
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THE RESULTS OF A CONFERENCE BASED UPON THE "DEVELOPMENT OF CRITERIA OF SUCCESS IN SCHOOL ADMINISTRATION" PROJECT (COOPERATIVE RESEARCH PROJECT, NO. 214) ARE REPORTED. THE ADMINISTRATIVE PERFORMANCE OF ELEMENTARY SCHOOL PRINCIPALS WAS THE MAIN AREA OF CONCERN. THE ACTIVITIES REPORTED INVOLVED STUDY OF THE REPORT AND OBSERVATIONS IN A SIMULATED SITUATION. THE CRITICISMS, RECOMMENDATIONS, AND PRIORITIES OF RESEARCH WORK ARE PRESENTED, INCLUDING A DISCUSSION OF SIMULATION AND MODELS TO BE USED IN BUILDING THEORY. AN ANNOTATED BIBLIOGRAPHY OF MODELS IS CONTAINED IN THE REPORT APPENDIX. (RS)

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(E-1 SAE 9061)

TEACHERS COLLEGE, COLUMBIA UNIVERSITY

Daniel E. Griffiths

The research reported herein was supported through the Cooperative Research Program of the Office of Education, U. S. Department of Health, Education, and Welfare.

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CHAPTER I

INTRODUCTION

With the completion of a major research project comes the question "What research is suggested by the study?" All too often researches are completed and stacked in neat rows on the library shelf. Dr. David Clark, Director of the Cooperative Research Branch (CRB) of the U. S. Office of Education, felt that something should be done about this commonplace, but distressing result. After consulting with researchers in education and with the Advisory Committee of the CRB there was developed the idea of research development grants. There would be different types of research development projects; the one being reported was to develop research based upon a major project funded by the CRB. There would be four in the first year, 1960-61. They would be small, yet adequate to allow a researcher time to build towards a project.

This present project is based upon the Development of Criteria of Success in School Administration Project (DCS), a study of the administrative performance of elementary school principals.[1] The plan of this project was relatively simple; there were two types of activity. One type involved study of the report by the research staff and a selected group of consultants, followed by a conference. The second type of activity was predicated on the notion that the DCS project was essentially an observation of the behavior of administrators in a simulated situation. It was not a theory-building effort. The DCS project had three objectives:

1. To determine dimensions of performance in the elementary school principalship and thus to develop a better understanding of the nature of the job of the school administrator.

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[1] Contract No. 214 (6905) U.S. Office of Education, Cooperative Research Branch entitled Development of Criteria of Success in School Administration Project.

2. To provide information helpful in the solution of the problem of selecting school administrators.
3. To provide materials and instruments for the study and teaching of school administration.

Of the three, only the first was the object of intensive work; the other two were considered as potential outcomes. It was reasoned that since the DCS project was an observation it should be followed by an effort to develop a theory or set of theories which would aid in the explanation of the observations. The second type of activity was an effort towards theory building.

Procedures

As the final report of the DCS project neared completion the research staff considered the question of who might be invited to read and criticize the report and who might well offer suggestions for further research. It was thought that the consultants might well be doing research into which the results of the DCS project might tie. In addition, the consultants should be from the behavioral sciences or professions which are directly related to the content and methodology of the project.

With these criteria in mind the following were invited and accepted:

Roald Campbell, School Administration, University of Chicago

Neal Gross, Sociology, Harvard University

Harold Guetztrow, Psychology, Sociology, and Political Science, Northwestern University

Samuel Messick, Personality, Educational Testing Service

The four consultants each analyzed the report and developed research ideas in terms of their specializations. A conference was held at the Hotel Claridge, Atlantic City on June 5, 6, 7, 1961. Present at the conference in addition to the consultants were members of the research staff:

Daniel Griffiths, Teachers College, Columbia University

John Hemphill, Educational Testing Service

Norman Frederiksen, Educational Testing Service

Laurence Iannaccone, Washington University, St. Louis

William Coffield, University Council for Educational Administration

Dr. David Clark attended both as a participant and as an evaluator of the possible general use of the technique of the follow-up conference.

Each of the consultants took a half day to present his critique for discussion. The third day was devoted to a consideration of research growing out of the project.

The theory-building activity (objective 2) centered on a search of the literature. The actual search was undertaken by Mr. Robert Kelley, graduate student of Teachers College, Columbia University. All relevant fields of inquiry including mathematics, sociology, psychology, economics, political science, education, and biology were included. As the search proceeded papers were written by Griffiths which were criticized by four seminars:

1. Faculty Seminar on Educational Theory, Teachers College, Columbia University, sponsored by the Horace Mann Lincoln Institute of School Experimentation (1960-61)
2. Research Seminar, University of North Carolina, sponsored by the University Council for Educational Administration (April 10-19, 1961)
3. Research Seminar, University of Chicago, sponsored by the University Council for Educational Administration (May 8-12, 1961)
4. Research Seminar, University of California, Berkley, sponsored by the University Council for Educational Administration (August 27-31, 1961)

The products of this phase of the work are an annotated bibliography on models, a paper on the use of models in research on educational administration, and a paper using one of the models, systems theory, as illustrative of the direction which might be taken in theory building. All of these products are incorporated into this report.

The DCS Project

The following is a brief description of the DCS project.[2] The project had three major objectives:

1. To determine dimensions of performance in the elementary school principalship and thus develop a better understanding of the nature of the job of the school administrator.
2. To provide information helpful in the solution of problems of selecting school administrators.
3. To provide materials and instruments for the study and teaching of school administrators.

The study was divided into six stages, and began with a survey of job descriptions of the elementary school principalship and a conceptual analysis of the task of the school administrator. As a result of this work a 12 cell grid was constructed and served as a way of organizing various aspects of the principals' job. The second step entailed the development of a rather unique research tool; a simulated situation called the Whitman School. The school was located in the Town of Jefferson in the State of Lafayette. Background materials were produced so that the subjects could be taught the important feature of the school in a day and a half. Special tests called in-baskets, kinescopes, tape recordings, and motion pictures were produced to present administrative problems in a simulated school situation. In other words, a standard administrative situation was constructed and 232 principals from all over the country became the principal of Whitman School. In addition, several published tests of abilities, knowledge, interest, and personality were administered to the subjects. Other instruments were constructed to obtain information regarding the experience, training, and performance of the subjects in the test situation.

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[2] Published in two forms: Dimension of Administrative Performance Contract No. 214 (6905), Cooperative Research Branch, United States Office of Education and John Hemphill, Daniel Griffiths, and Norman Frederiksen, Administrative Performance and Personality (New York: Teachers College Bureau of Publications, 1962).

The third and fourth steps in the study consisted of preliminary tryout of all tests and the administration of same at centers located across the country.

The fifth step of the study was concerned with the scoring and analysis of the products of the work of the principals. The 40 most reliably-scored categories were factor analyzed. The factors were then related to other measures of the principals' mental ability, knowledge, personality, interests, and the like. Finally, a special use of factor analysis permitted detailed examination of relationships among all of the major variables of the study and the unique components of the administrative performance factors.

Outline of Report

Chapter 2 of this report deals with the results of the Atlantic City Conference. It will deal with criticisms of the DCS project only in a very general way. A categorization of research is presented followed by an elaboration of the varieties of research suggested by the DCS project. There is also a brief discussion of the matter of priorities or strategy of research work.

Chapter 3 is built around the idea that simulation is a highly effective method for investigation into administrative behavior and that simulation is a most effective method of testing theories of administrative behavior. Therefore, the chapter contains a discussion of simulation and models which might be used in building theory. Some models are presented and discussed in detail.

The appendix contains an annotated bibliography of models which might be used in theory building in administration.

CHAPTER II

POTENTIALS FOR RESEARCH IN THE DCS PROJECT

Potential research suggested by the DCS project is discussed under four headings:

1. Exploitation of present data
2. Extension of the DCS study through replication
3. Extension of the DCS study into new areas
4. Testing empirical regularities found in the DCS study.

Exploitation of Present Data

A vast amount of data was collected in the DCS project. While a great deal of analysis was done much more could be done. The cheapest and easiest research that could be done is the exploitation of data which has been collected. This research would be quite valuable since it could readily be related to the results of the DCS project and, of course, to other relevant research.

Biographical Data

A 40 page Personal History Blank was included as one of the instruments in the data gathering process. The blank is divided into five parts:

Part I	General Family and Background Data
Part II	Period up to 12 Years of Age
Part III	Period between 12 and 18 Years of Age
Part IV	Period after 17 Years of Age and During College
Part V	The Present Time

No general analysis of the blank was done in the DCS project. However the blanks were partially processed by Dr. Andrew Halpin of the University of

Utah.[1] In commenting on the usefulness of the data Halpin points out:[2]

> The Personal History Blank was included in the test battery solely on an exploratory basis and not because anybody expected to secure a plethora of "predictors" from it. But we need not have been so pessimistic. At even the most primitive level of analysis - in terms of the sheer number of statistically significant correlation found between specific biographical items and performance variables - the personal history data have proven illuminating. Indeed, the salient conclusion of the present study is that biographical information is worth collecting - that we would make a serious mistake were we to be cavalier in dismissing biographical information as a potential predictor of administrative "effectiveness."

Halpin correlated the 216 responses to 69 of the questions in the Personal History Blank with 23 variables from the DCS project. Since men and women were run separately a total of 9,844 correlations were computed. A total of 1598 correlations were significant at the .05 level or above. This is far in excess of the number (295) which could be expected to occur by chance alone. In view of the fact that Halpin did not use some of the variables such as scores on professional knowledge tests, job performance values, instructional awareness scores, speech scores, or the second order performance factors which were among the most useful in the parent study his results are most encouraging.

Halpin's study had three purposes:[3]

1. to describe a particular sample of elementary-school principals in terms of their personal history,
2. to analyze the relationship between specific biographical items and several criteria of "success" in the principalship, and
3. to generate from the present findings new hypotheses which will permit us to make better predictions of administrative "success" from biographical information.

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[1] Andrew W. Halpin and Don B. Croft, The Biographical Characteristics of Elementary-School Principals, unpublished mimeo report. Project financed by University of Utah Research Committee and the Kellogg Foundation.

[2] Ibid., p. 104.

[3] Ibid., p. 5.

A very useful project would be one which could be built upon the Halpin study. The following steps should be taken:

1. Score the entire Personal History Blank
2. Compute first order correlations between variables from the Personal History Blank and composite factor scores
3. Relate the variables from the Personal History Blank to following variables:[4]
    - (a) Thirteen superiors rating items describing the principal's performance in his regular position. (Chapter XI)
    - (b) Three scores based on teachers' questionnaire descriptions of their principal. (Chapter XI)
    - (c) Two over-all ratings, one made by members of the research staff and the other by in-basket test scorers. (Chapter XI)
    - (d) Twelve categories of instructional awareness that were expressed by the principals in response to the kinescopes which showed probationary teachers in their classrooms. (Chapter IX)
    - (e) Six categories of job performance values based on the special educational problems that were presented by means of tape recordings. (Chapter IX)
    - (f) Ten group interaction categories from the group interaction problem. (Chapter X)
    - (g) Ten speech categories from the tape recording of the speech, "The Value of Education in America". (Chapter X)
    - (h) Sixteen basic mental ability test scores. (Chapter V)
    - (i) Four scores from the tests of professional and general knowledge. (Chapter V)
    - (j) Five background achievement test scores from a test of what the principal learned during his study of the background material. (Chapter V)
    - (k) Fifteen basic personality factors. (Chapter V)
    - (l) Ten scores from the scorers check list. (Chapter XI)

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[4] Chapter numbers refer to chapters in John Hemphill, Daniel Griffiths, and Norman Frederiksen, Administrative Performance and Personality (New York: Teachers College Bureau of Publications, 1962).

(m) Twelve background orientation scores (values).

(n) Eighteen scores from the Strong Interest Inventory Blank. (Chapter V).

(o) Twenty-five in-basket category scores which were not included among the 40 upon which the factor analysis was based.

4. Through the use of the technique used in Chapter XIII relate selected variables to the components of the administrative performance factors.[5]

Samples of Writing

There have been two studies made of the samples of writing submitted by the principals, both under Halpin's direction.[6] Dayley tested the hypothesis that significant relationships exist between test scores of verbal knowledge and the written language indices derived from an analysis of the principals' written compositions, and between test scores of fluencies and the written language indices. Eleven of 30 possible correlations were found to be significant. Miller described the written language abilities of the principals in terms of several quantitative measures of language, determined several significant relationships among quantitative measure of language, found no relationships between language indices and biographical variables, but found that correct usage was related directly to success as a principal.

While both studies are limited in scope, they do indicate that the two written samples, an article for the local newspaper and an article for the school magazine, are fruitful sources of information.

Several types of analysis might be undertaken. Each article could be scored using the in-basket scoring categories used in the DCS project. The written material might well yield interesting results when so viewed. Johnson has derived a number of language measures which could be used to score the written samples. Some of these are:[7]

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[5] Ibid.

[6] Alan Jay Dayley, The Relationship Between Test Scores on Vocabulary and Fluency and Language Indices Based Upon Written Compositions, unpublished Master's Thesis, University of Utah, 1961. Marcella M. Miller, A Psychological Analysis of Written Compositions of Elementary School Principals, unpublished Master's Thesis, University of Utah, 1960.

1. Type-Token ratio - a measure of vocabulary flexibility.
2. Type Frequencies - An objective measure of the use of each different word or type of word.
3. Proportionate Vocabulary - The number of different words or types that make up a given fraction of a given language sample.
4. Standard Frequency Vocabulary - Word counts to establish the rank order of frequency of use of words.
5. Verbal Output - Number of words.
6. Word Length - Number of letters per word.
7. Sentence Length - Number of unit words per sentence.
8. Measures of Allness - Frequency of allness terms e.g. all, nobody, never.

The written work could be scored and the scores correlated with measures from the DCS project. This would then "tie in" this research with significant work in the field of general semantics.

It appears to be clear that the written material could very well serve as the basis for a number of researches.

Rescoring of Basic Data

Various sets of data were scored by various methods. A 68 category scoring system was developed for the in-basket items,[8] while the kinescopes, tape recordings, interaction problem, and speech were all scored by separately developed scoring methods.[9] While the latter scores were correlated with factor scores it might be well worthwhile to rescore the responses to the kinescopes, tape recordings, and speech using the in-basket scoring categories. This would give a common base to several measures of administrative performance.

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[7] Wendell Johnson, People In Quandries (New York: Harpers, 1946), pp. 499-518.

[8] Administrative Performance and Personality, op. cit., Chapter VI.

There is enough of a discrepancy between results obtained from different methods of data gathering to raise the question of why this is so. For instance, there is little relationship between measures of Initiating Structure in Interaction and Consideration as measured by the Principal Behavior Description Questionnaire (PBDQ) and in-basket scoring categories of the same name. This may be due to scoring rules which were not congruent to items in the PBDQ or it may be due to the fact that there is so little Initiating Structure and Consideration in administrative performance that it can be scored only infrequently in in-basket responses. Whatever the reason, it would be well to score all instruments which measure administrative performance with the same scale.

School Administration and Supervision Test

One of the standardized measures administered to the subjects was the School Administration and Supervision Test which was compiled and distributed by the National Teachers Examination, Princeton, N.J. This test presumes to measure a person's ability to be a school administrator and it correlated rather highly with a number of performance measures. This test could well be analyzed and its factors related to the factors from the analysis of in-basket performance. This would indicate more precisely what the test contains. It also might show that there is a factor missing in one or the other.

9/ *Ibid.*, Chapters IX and X.

Extension of the DCS Project Through Replication

A question which must be asked is, If the study was replicated would the same factors appear? The answer to this is, of course, not known. It is our best guess that they would appear again because the sample of principals appear to be highly representative of elementary principals the country over and the measures were all adequately reliable. However, as in all studies there remains the question of replication.

Since studies in behavioral science are repeated so infrequently it would seem that this would be a fine study to replicate. The report of the study is sufficiently detailed so the all of the steps could be duplicated, the instruments and tests are available, and there would appear to be no obstacles to a replication of this study. Aside from the value of starting a movement towards replication in the social sciences, which in itself is highly desirable, it would be very interesting to note whether or not the same factors would emerge from a replication of this large scale factor analytic study.

Extension of the DCS Project into New Areas

It would certainly appear that the technique of the simulated situation combined with computee analysis, factor analytic and other advanced statistical methods, plus new models such as system-theory gives to the researcher powerful tools for examining deeply the administrative process. There are two broad areas in which research should move immediately; other levels or classes of administration and other domains of variables. These two areas need not be investigated separately since they are not mutually exclusive, but may, in fact, reinforce each other.

Other Levels

Simulation would appear to be an appropriate instrument to investigate several other positions. In public schools the positions of high school principal, superintendent of schools, school business and other central office administrators are particularly susceptible to inquiry. At present, investigation into these positions has been done by survey or by testimonials. They could well be studied in much the same way as was the elementary school principal.

An area of administration as little studied as the Tibetan wastelands is that of the college and university. Having recently taken a position as associate dean it seems that the in-basket is extremely appropriate to the study of administrative positions in higher education. It would appear that administrators at this level work with paper to a greater extent than do public school administrators. Contacts with people either singly or in groups could be simulated also.

While there are many other positions that could be studied, the extension to cover other administrative positions in the public schools and higher education is a logical extension level wise and should receive first priority.

New Variable Domains

The variables employed in the DCS study were largely psychological. Succeeding studies should employ a wider domain of variables and without question should include what are commonly referred to as sociological variables. A number of sociological variables were controlled: superordinate and subordinate definition of role of the principal, performance of superordinates, communication structure, community and faculty norms, role of the board of education, social setting of both the faculty and the community and the competency of the staff. Other sociological variables are of consequence and should be explored.

An assessment should be made of the expectations of the subjects so that each subject would develop his own role definition. Certainly the social class background of each subject should be determined. While past work in values has not been too successful, there should be something to the study of values. At least, it could be determined if values are related to administrative performance and, if so, what values.

The above is a rather feeble effort to encompass the field of sociology. Further studies of the type contemplated should include a sociologist on the staff.

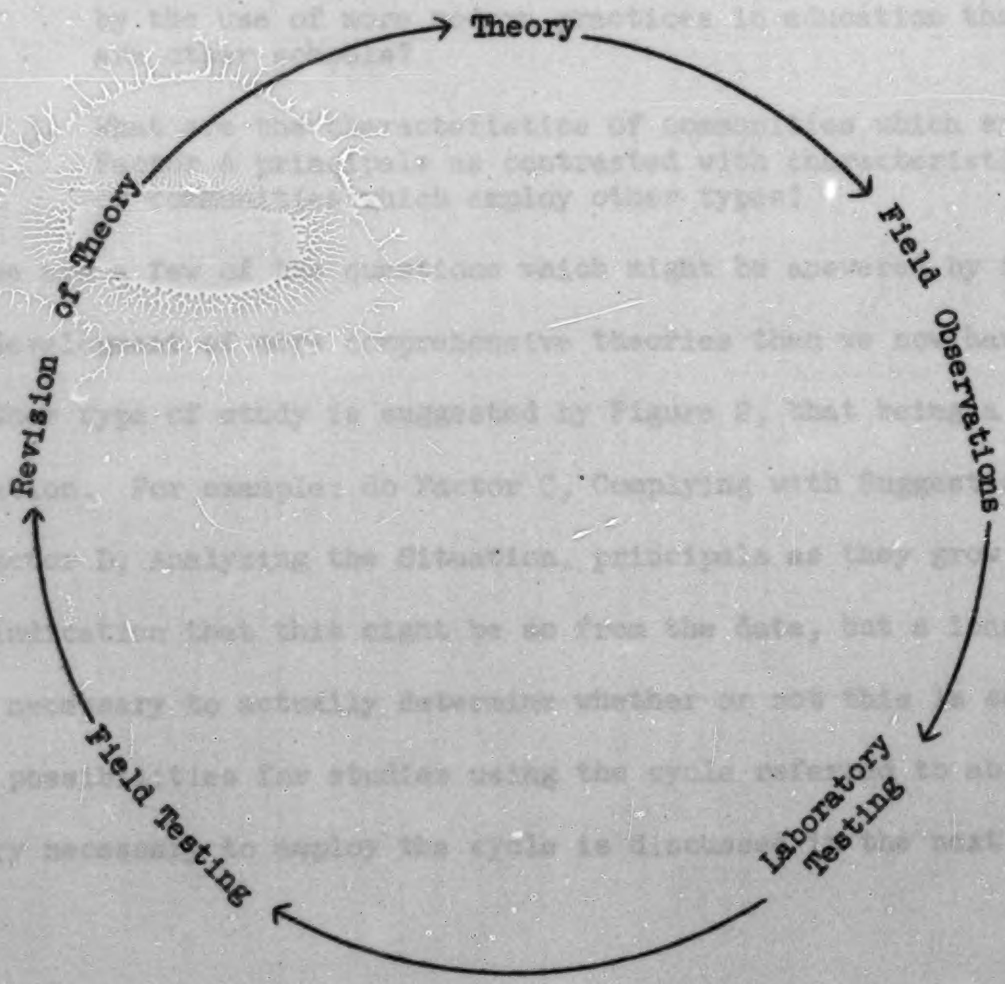
Testing Emperical Regularities found in the DCS Study

Probably the chief value of simulation is that it is a laboratory in which practically any variable can be tested or controlled. Until recently the lack of such a laboratory has been a serious obstacle to progress in the study of behavior. Fruitful research in administration should be cyclic in nature. Observations should be made in the field, brought into the laboratory and developed into precise hypotheses which are then brought back into the field for further testing. When in the laboratory the observations should be checked against existing theory and against newly developed theory. Following the field testing, the hypotheses would be incorporated into theory. Figure 1 shows the suggested cycle.

A very large number of empirical regularities are available for field testing. Figure 2, taken from Chapter XIII of the report of the DCS project, follows and contains in summary form the major regularities which can be considered as hypotheses for field testing. As an example: some principals were identified as being high on a type of administrative performance called Factor G, Responding to Outsiders. This type of principal was found to be ineffective in the interaction situation in the DCS simulation. The questions for field testing are: can some principals be accurately described as Factor G principals and are they indeed ineffective in interaction situations?

Figure 1

The Cycle of Research in Administrative Performance


Theory
Field Observations
Laboratory Testing
Field Testing
Revision of Theory

Another line of inquiry should also be moved forward and can only be done so in the field. The question raised is: Suppose there is a type of principal whose performance can be characterized as Factor A (for example), that is, high in Exchanging Information, what are the consequences of this type of performance in the school being administered? We know that Factor A principals gain very favorable reactions from their superiors and favorable reactions from their teachers, but what are the other consequences of Factor A performance? Some questions are:

1. Do the students of Factor A principals achieve at a higher level than students of other principals?
2. Are schools administered by Factor A principals typified by the use of more modern practices in education than are other schools?
3. What are the characteristics of communities which employ Factor A principals as contrasted with characteristics of communities which employ other types?

These are a few of the questions which might be answered by field testing and the development of more comprehensive theories than we now have.

Another type of study is suggested by Figure 2, that being a longitudinal investigation. For example: do Factor C, Complying with Suggestions, principals become Factor D, Analyzing the Situation, principals as they grow older? There is some indication that this might be so from the data, but a longitudinal study is necessary to actually determine whether or not this is so.

The possibilities for studies using the cycle referred to above are great. The theory necessary to employ the cycle is discussed in the next chapter.

FIGURE 2. SUMMARY OF RELATIONSHIPS WITH THE UNIQUE COMPONENTS OF IN-BASKET PERFORMANCE FACTORS

PERFORMANCE ON IN-BASKET PROBLEMS	ABILITIES AND KNOWLEDGE	PERSONALITY, INTEREST, AND VALUES	PROFESSIONAL CONCERNS	INTERACTION PERFORMANCE	BIOGRAPHICAL DATA	EVALUATIONS
Factor X, Preparation for Decision	Fluent, facile with symbolic material, sees associations quickly, good at reasoning, knows school administration, elementary education, science, and fact about the general cultures, learns new material rapidly	Values educational needs of pupils. Interests similar to psychologists and lawyers	Concerned with most areas of teacher performance; especially objectives, planning, methods, teacher personality, pupil motivation and child growth	Active and effective in group discussion, suggests new procedures	(Not related)	Superiors--positive, staff members--positive, scorers--strongly positive
Factor Y, Amount of Work	Over-all high ability, fluent with words and ideas, knows elementary education, school administration, cultural and scientific material, learns new material rapidly	(Not related)	Concern with curriculum, child growth, teacher personality, personnel problems	Effective in interaction, talks a lot, tries to influence	(Not related)	Superiors neutral to slightly positive, staff members positive, scorers strongly positive
Factor A, Exchanging Information	Has great verbal knowledge and facility, knows elementary education, school administration and facts about the general culture	Sociable, sensitive, trusting, confident, and relaxed. Interests like, superintendents, lawyers or psychologists, unlike, policemen	Concerned with teacher and pupil personnel problems, especially with the reaction of pupils to the educational program	(Not related)	More characteristic of women	Superiors--very positive, teachers--positive, scorers--positive
Factor B, Discussing Before Acting	(Not related)	Mature, self confident, and relaxed. Interests like policemen and public administrators	(Not related)	Reluctant to participate, regarded as ineffective	Little administrative experience	Superiors--negative, teachers--negative
Factor C, Complying with Suggestions	Ability to reason and sees relationships, knows general cultural facts, science and mathematics, learns new material rapidly	Aloof, shy, practical, skeptical, independent, insecure, unstable and tense. Interests like policemen, unlike school superintendents	Not concerned with objectives, evaluation, planning and continuity, curriculum, or child growth and development	(Not related)	Young, little experience, more characteristic of men	Superiors--very negative, teachers--negative
Factor D, Analyzing the Situation	Ability to reason and see relationships, knows general cultural facts, science and mathematics	Aloof, dominant, practical, shrewd, feels pressure. Interests like policemen and public administrators	Not concerned with classroom climate or routines	Participates fully and moderately effectively, talks a lot and suggests new procedures	Has administrative experience, more characteristic of men	Superiors--negative, teachers--negative
Factor E, Maintaining Relationships	Slow in seeing relationship, lacks knowledge of science and mathematics	Sociable, lively, sensitive, confident, dependent, and relaxed. Interests of superintendents and lawyers	Concerned with instructions, curriculum, personnel, public relations	Participates fully and effectively	More characteristic of women	Teachers--very positive
Factor F, Organizing Work	(Not related)	Easily frustrated, inflexible, shy, skeptical, insecure, unstable, and tense. Interest unlike superintendents, administrators and psychologists	Concerned with pupil reactions, physical setting of classroom	Emphasized positive information in interaction, not effective	(Not related)	Superiors generally negative, teachers positive regarding initiating structure
Factor G, Responding to Outsiders	Lacks general ability, lacks knowledge of science and mathematics, school administration and general culture	Submissive, subdued, shy, naive, stable and relaxed. Interest unlike public administrators and lawyers	Concerned with the objective, planning, evaluation, planning and effects of teacher performance	Does not participate, regarded as ineffective	Has large amount of teaching experience, older, characteristic of women	Superiors neutral to slightly negative, staff members negative
Factor H, Directing Others	Lacks knowledge and ability, unable to learn new material quickly	Sober and stable. Interests unlike school superintendents and lawyers	Concerned with objectives but not personnel or pupil reactions	(Not related)	Has experience in education, older	Teachers--negative

CHAPTER III

SIMULATION AS A RESEARCH TOOL

If the DCS did nothing else it has demonstrated the value of simulation as a research tool. While it is certainly not the ultimate instrument for truth in school administration it is a tool which should be used far more than at present. It should certainly be admitted at this point that the simulation employed in the DCS project, while very useful, is but the first step towards the simulation that is technically possible at the present time.

There have recently been a sizable number of simulations developed in various fields of inquiry. It seems strange that education, the field that could use simulation most effectively, is the one field in which it is almost completely lacking. Education is so susceptible to study by simulation because schools the country over are so similar. A school in Los Angeles, for instance, may have the same number of students, the same number of teachers, the same administrative structure, the same lessons being taught from the same textbooks at the same time of day as a school in New York. There are certain obvious differences such as the ethic background of students and the educational background of the teachers, to mention only two. There may be other differences such as teaching methods, quality and type of teaching aids, and the degree of supervision of instruction. With the present level of knowledge we do not know what are the variables which make a difference in the learning of children. Simulation offers an approach to solving problems of this sort.

Simulated schools could be built either with or without computers, in which the effect of numerous variables could be tested. The case for such constructions is well put by Chapman and Kennedy:1/

1/ Robert L. Chapman and John L. Kennedy, "The Background and Implications of the Rand Corporation Systems Research Laboratory Studies." Some Theories of Organization, ed. by Albert H. Rubenstein and Chadwick J. Haverstroh (Homewood, Illinois: The Dorsey Press, Inc. and Richard D. Irwin, Inc., 1960), pp. 140, 141.

> The Systems Research Laboratory's facilities are used to study human organizations in much the same way a wind tunnel is used in developing new aircraft. In both methods the experimenters manipulate an environment to apply stress to highly detailed models so that the performance of the prototype can be predicted and changes made to improve it. A wind tunnel uses a detailed scale model of the aircraft whose flight characteristics are being studied; the Systems Research Laboratory used a model organization of 30 to 40 men that was practically full scale. By exposing the models to critical environmental conditions, over and over again in different combinations, both facilities can be used to expose weak points in the design of the prototype.
>
> Both wind tunnels and this way of studying organizations rely heavily on elaborate measuring devices. And both of them accumulate enormous amounts of data -- so much, in fact, that a corps of specialized, technical, and clerical workers is needed to handle it.
>
> Research facilities such as the Systems Research Laboratory, again like wind tunnels, are big and expensive, but they may well become as indispensable in designing and improving systems as wind tunnels are in designing aricraft.

As of now System Development Corporation appears to be the only institution actively working on the development of a simulated school.[2] The SDC school will be used to study instructional, counseling, and administrative problems. There should be a large number of such installations, rather than just one.

Types of Simulation

A review of various types of simulation should be of value to our discussion of research on problems in educational administration. Recent work by Meier points up the almost endless possibilities inherent in inexpensive simulation.[3] While Meier discusses the teaching values in these simulations, he does use certain of them for research purposes and the point is that all could be so used.

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[2] David G. Ryans, Education Research and Development at System Development Corporation (Santa Monica: Feb. 1962 SP-715).

[3] Richard L. Meier, "Teaching Through Participation in Micro-Simulation of Social Systems," a paper presented at the American Association for Advancement of Science, Denver, 1961.

Wildlife

Meier defined simulation as a simplified, often stylized representation of some existing system. A system being defined as a set of inter-related parts whose state may change over time, while a social system comprises the integrated behavior of a body of actors. He used the term micro-simulation to denote simulations which do not require computers or elaborate gear.

One such simulation is called "Wildlife" in which animals are moved about on a chessboard so as to satisfy elemental drives such as hunger and thirst, reproduce, and fight battles with other species. As a teaching device Wildlife helps the student to connect ecology and population dynamics with other principles of biology and adaptive behavior. As a research tool it offers insights into conditions leading to stability and growth of social organizations, as opposed to those leading to decline and disruption. It is possible, through a simulation such as Wildlife, to present theory in a form that emphasizes the dynamic elements of processes like growth, development, and adaptation of a social institution and to test hypotheses derived from the theory.

Gusher

Grayson has developed an interesting game called "Gusher" which is a simulation of a potentially productive oil and gas area and the rules of play are designed to present participants with decision-making situations that approximate, as closely as possible, decisions found by operators in the industry.4/

4/ C. Jackson Grayson, Jr., Decisions Under Uncertainty (Cambridge, Harvard Graduate School of Business Administration, 1960), pp. 353-371.

Physically Gusher is a box 42" x 42" x 4" with two holes drilled in every 1" x 2" rectangle on the top surface. Under the surface and unseen by the players are two boards filled with holes in the same fashion as the top surface. However, the referee may block off certain of these holes with a template so that when a rod is pushed through the top surface it strikes the template and a productive well is simulated. When the rod is allowed to plunge down freely, the result is a dry hole.

The game is played by giving the players a geological report and a certain amount of money. The point of the game is to make decisions as to where to drill that are comparable to decisions made on oil fields. Grayson discusses the research possibilities of Gusher as follows:[5]

> 1. Simulation of relatively "pure" logical situations to gain insight or to test hypotheses regarding decision theory could be valuable. For example, the problem of "when to quit" could easily be simulated by arranging the board with no oil, or no deep oil, or only uneconomical amounts of oil (all this, of course, not known to the players). Similarly, the problem of giant fields with vanishingly small probabilities of existence might be studied effectively by setting up a board of marginal economics except for a single well location which, in some games, is worth more than the rest of the board put together.
>
> 2. Study of the "ruin" problem for persons taking risks with limited funds might be feasible. Initial starting conditions and decision rules could be varied to observe outcomes.
>
> 3. Simulation of joint strategies might provide a case study of coalitions. Particularly of interest, in this regard, might be the study of the optimum times of association in a coalition - and of disassociation - and of the effects of treachery (broken agreements, simultaneous participation in two coalitions), etc.
>
> 4. Study of the human as a decision maker (as opposed to an analytic formulation of decision making) might be a goal. In particular, comparison of actual play with "logical" play might provide insight into human decision making. Such insights in turn might help improve the

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[5] *Ibid.*, p. 368

> analytical formulation, particularly in those cases where the human does better than is indicated by the analytical model!

Community Model Game

A simulation similar to what is needed in school administration is that of Grundstein and is described as follows:[6]

> The design of the game will incorporate a mathematical model of a selected community with well defined characteristics. The play of the game simulates the administration of a community over an extended time period - 30 years. The community selected as the subject for play is a partially developed geographically bounded, autonomous suburban political unit with definite functional relationships between resources, demand levels for services, costs, output of services, and socio-economic characteristics of its population which can be expressed in mathematical form.
>
> The play of the game introduces the social preferences of the players (the factor of utility or value) which will be expressed through a sequence of decisions over time reflecting preferred outcomes concerning the present and future course of development of the city. By varying the clientele who will play, the outcomes will not be confined to the social preferences of the professional or career administrator. The players are not obligated to play for the ideal payoff of the planner. Freedom of play for the players--that is, freedom to utilize their own social preferences as to outcomes--is thus introduced into the game. At the termination of game play, the players can be exposed to criteria which will serve as norms for their own evaluation of their own criteria of play. The "success criteria" are thus outside the computer and function as learning devices. There is no optimum play. There is competition between players representing different clientele who have different social preferences which will result in different outcomes as respects the development of the community over time.

This game enables one to teach a wide range of decision behavior and could, of course, lead to a great deal of research. The Community Model Game provides for organizing, allocation, financing, priorities, strategy, and research decisions. Figure 3 diagrams the flow of information in the computer for the players' decisions.

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[6] Nathan D. Grundstein, University of Pittsburg. Paper prepared for delivery to the annual meeting of the American Association for the Advancement of Science, Denver, Colorado, December 29, 1961. Section L, Philosophy of Science, "Symposium on the Teaching of Systems Thinking".

Simulation, Theory, and Models

It is proposed that a simulated school be built in which could be tested a wide variety of models. Experience gained in building the DCS simulation would be put to work in the new project.

Pros and Cons of DCS Simulation

In the DCS project the simulation centered upon the Whitman School. The subjects were given one and a half days of instruction so that they could become acquainted with the school and its community. The method of working in the simulation was the "in-basket" in which each subject received some 32 items, that is, typical incidents which might occur in a school. The items consisted of telegrams, letters, memos, reports, requisitions, etc. The subjects responded to the items as they pleased, but did so in writing. Additional problems were presented in kinescopes of teachers in the classroom and in tape recordings of conferences, schoolboard meetings and the like.

The major shortcoming of the in-basket simulation was the lack of feedback. In actual situations many of the problems that must be dealt with are created by the acts of the administrator. As he receives information he acts in some way, then more information comes to him as a result of this action and the process continues. There was no feedback in the in-basket situation so that the subjects were never aware of the results of their action. This was intentional in the DCS study since the project attempted to determine how the subjects handled a number of administrative incidents.

Another difficulty, from the point-of-view of replication of an actual

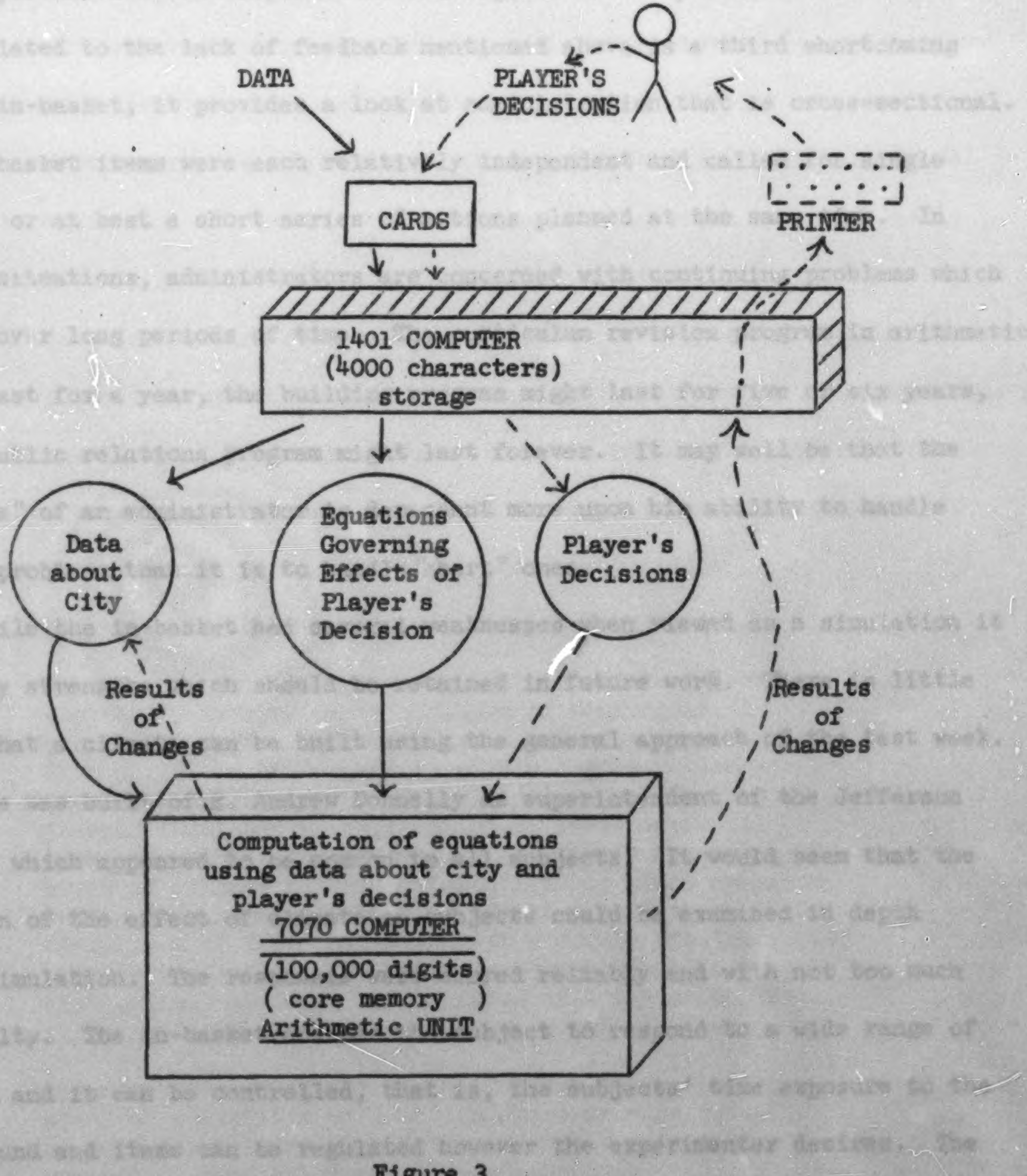
DATA
PLAYER'S DECISIONS
CARDS
PRINTER
1401 COMPUTER
(4000 characters)
storage
Data about City
Equations Governing Effects of Player's Decision
Player's Decisions
Results of Changes
Results of Changes
Computation of equations using data about city and player's decisions
7070 COMPUTER
(100,000 digits)
(core memory)
Arithmetic UNIT

Figure 3

Flow of Information in the Computer for Player's Decisions

- - - - indicates play of the game

administrative situation, was the fact that all of the subjects worked independently. While all administrators do some independent work they probably do more work with other people. A realistic simulation should provide opportunities for subjects to work together as they administer.

Related to the lack of feedback mentioned above is a third shortcoming of the in-basket; it provides a look at administration that is cross-sectional. The in-basket items were each relatively independent and called for single actions or at best a short series of actions planned at the same time. In actual situations, administrators are concerned with continuing problems which extend over long periods of time. The curriculum revision program in arithmetic might last for a year, the building program might last for five or six years, and a public relations program might last forever. It may well be that the "success" of an administrator is dependent more upon his ability to handle "long" problems than it is to handle "short" ones.

While the in-basket had several weaknesses when viewed as a simulation it had many strengths which should be retained in future work. There is little doubt that a climate can be built using the general approach of the test week. An image was built of E. Andrew Donnelly as superintendent of the Jefferson Schools which appeared to be common to all subjects. It would seem that the question of the effect of climate on subjects could be examined in depth using simulation. The responses were scored reliably and with not too much difficulty. The in-basket enables the subject to respond to a wide range of stimuli and it can be controlled, that is, the subjects' time exposure to the background and items can be regulated however the experimenter desires. The in-basket can also be complemented through use of film and tape recordings to include much that is typical of the administrators work. It would seem that an adequate simulation could be built with the in-basket technique as its basis.

Theory

Prior to discussing the mechanics of the school simulation let us introduce the way in which the simulation is to be used. It is proposed that the simulated situation be used to develop theories of administration and to do this in a rather formal manner. Both students and practitioners of school administration are much concerned with the theoretical aspects of administration, but this concern is a preoccupation more with the scientific study of administration than with theory construction. The interest therefore is in making inquiry in administration conform to the tenets of science. Work in administration is becoming more and more characterized by a concern for objectivity, reliability, operational definitions, systematic structure, comprehensiveness, and parsimony. When work conforms to these criteria it can more nearly approximate the aim of science which is to accomplish three things with its subject matter: description, explanation, and prediction.

The word theory is used in the way suggested by Fiegl:[7]

> In order to provide for a terminology which will not constantly involve us in a tangle of confusions, I propose to define a "theory" as a set of assumptions from which can be derived by purely logico-mathematical procedures a larger set of empirical laws. The theory thereby furnishes an explanation of these empirical laws and unifies the originally relatively heterogeneous areas of subject matter characterized by those empirical laws. Even though it must be admitted that there is no sharp line of demarcation (except a purely arbitrary one) between theoretical assumptions and empirical laws, the distinction, at least in the sense of a gradation, is illuminating from a methodological point of view.
>
> One more terminological suggestion may help: Let us speak of scientific explanation wherever more specific or more descriptive statements are derived from more general or more hypothetical assumptions.

7/ Herbert Fiegl, "Principles and Problems of Theory Construction in Psychology," in Current Trends in Psychological Theory (Pittsburgh: University of Pittsburgh Press, 1951), p. 182.

In essence, Fiegl proposes that theory be defined as a set of assumptions from which can be derived by purely logico-mathematical procedures a larger set of empirical laws. A number of questions might be raised concerning the definition: What is the meaning of set? What is the difference between assumptions and laws? Must a theory be tested before any indication of its value is known? What would be a theory which meets this definition?[8]

Set. As the term set is used here it means a set of assumptions such that (1) no other assumption can be derived from any other combination of assumptions in the set, and (2) the total set of empirical laws cannot be derived without the inclusion of every member of the set. A word which can be used as a synonym for set is totality so Fiegl is referring to all of the assumptions and all of the laws which can be derived.

Terminology. The language of theory building is very confusing. Concepts are used differently by practically all writers and there appear to be no authorities. It would seem that if some agreement could be reached it would be most helpful. With this in mind, the following is offered.

Figure 4 is an attempt to show certain significant terms and their relationship to one another. All theory has its beginnings in some sort of presumptions which are basic to and are prior to, assumptions. Some writers call presumptions principles, but this appears to be too confusing. Let presumptions remain presumptions. It can be said of presumptions that they are not empirical findings and are not directly derived from empirical findings,

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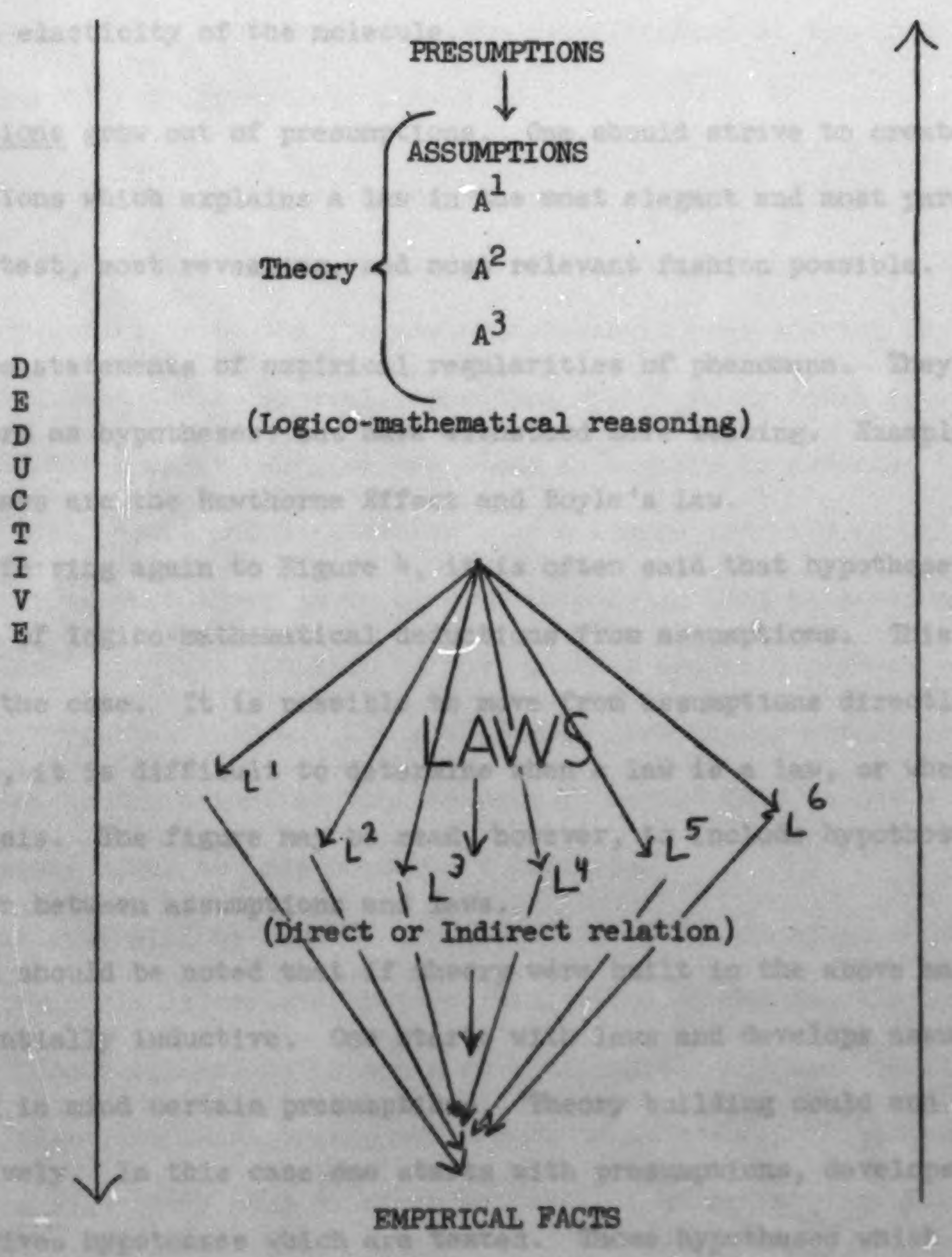
[8] I would like to acknowledge the help in clarifying the concept of theory received from participation in the Faculty Seminar on Educational Theory at Teachers College, Columbia University sponsored by the Horace Mann Lincoln Institute of School Experimentation 1960-61. The work of the Seminar was reported in Proceedings and other unpublished documents.

FIGURE 4


PRESUMPTIONS
ASSUMPTIONS
A¹
Theory
A²
A³
(Logico-mathematical reasoning)
DEDUCTIVE
INDUCTIVE
LAWS
L¹
L²
L³
L⁴
L⁵
L⁶
(Direct or Indirect relation)
EMPIRICAL FACTS

but they are ways of directing empirical findings. Often they are decisions. The only criterion that can be employed in the selection of presumptions is usefulness. If a presumption gives rise to assumptions upon which theory can be built, then it is retained, if not, it is abandoned. Examples of useful presumptions in physics are the straight line ray concept and the concept of perfect elasticity of the molecule.

Assumptions grow out of presumptions. One should strive to create a set of assumptions which explains a law in the most elegant and most parsimonious, the neatest, most revealing, and most relevant fashion possible.

Laws are statements of empirical regularities of phenomena. They have the same form as hypotheses, but have withstood more testing. Examples of well known laws are the Hawthorne Effect and Boyle's Law.

Referring again to Figure 4, it is often said that hypotheses are the outcome of logico-mathematical deductions from assumptions. This may or may not be the case. It is possible to move from assumptions directly to laws, in fact, it is difficult to determine when a law is a law, or when it is an hypothesis. The figure may be read, however, to include hypotheses in the position between assumptions and laws.

It should be noted that if theory were built in the above manner, it would be essentially inductive. One starts with laws and develops assumptions keeping in mind certain presumptions. Theory building could and does proceed deductively. In this case one starts with presumptions, develops assumptions and derives hypotheses which are tested. Those hypotheses which withstand test eventually become laws. Theory building generally proceeds in both ways. In either case, the set of assumptions is the theory.

Models

Probably the most efficient route to theory building is the employment of models as the starting point. Theory building is thus essentially deductive since one would employ a model as the starting point, deduce hypotheses, and run sufficient and adequate tests. Much of the research effort of the present project has been devoted to the clarification of the concept of models and the search for appropriate models.

Models. One of the most used words in social science research today is model. The impression gained from a reading of the literature and from listening to social scientists is that any somewhat systematic presentation of ideas is a model. A discussion is generally prefaced by, "Now, my model is..." Of course, if the speaker can give the ideas in numbers or symbols, then it is a "mathematical" model and much better than a common ordinary verbal model.

It may be that there is no harm in this -- so long as everyone knows what is going on. But this practice is just another academic perversion of a perfectly respectable idea. The real danger lies in the extrapolation of conclusions by the scientist when he uses a "model" that is not a model. This should become clear as this section is developed.

No attempt will be made to trace out all of the meanings of models which are in scientific literature, but we shall stand on the shoulders of those who have. Brodbeck appears to be the most intelligible and most scholarly of the writers interested in exploring the nature of models.9/ Since she defines model more rigorously than do other writers let us start with what she has to say.

9/ May Brodbeck, "Models, Meaning, and Theories," in Llewellyn Gross, ed., Symposium on Sociological Theory (Evanston: Row, Peterson, 1959), pp. 373-403. This is an excellent article and should be read by anyone interested in this topic.

Brodbeck points out that a statement of fact, a concept, a law, a theory, and a model are all different things. A fact is a particular thing, such as Johnny's I.Q. To state a fact is to state that a concept has an instance or a number of instances. When a fact is connected with other facts, a generalization or law is formed. As Brodbeck says, "A law states that whenever there is an instance of one kind of fact, then there is also an instance of another."10/ As an example of a law note the following: the distance a released body falls varies directly with the square of its time, that is, $d = 16 t^2$. A law is always an empirical generalization. A theory, on the other hand, is a deductively connected set of laws. Certain of the laws are the axioms or postulates of the theory and are usually called assumptions. Their truth is not so much self-evident as it is taken for granted, so that the truth of other empirical assertions called theorems can be determined.

It is necessary to diverge from the main point for a moment to introduce another idea, that being isomorphism. If X is a model of Y it is so because X is isomorphic to Y. Two conditions are necessary for this to obtain. First, there must be a one-to-one relationship between the elements of X and the elements of Y. Second, the elements of X must bear the same relationship to one another then the isomorphism is complete. For instance, if a model of a steam engine is also steam propelled, then the isomorphism is complete. The isomorphism of a planetarium with the heavens is not complete, however, since the motions of the planetarium are not caused by gravitational attraction. Thus, there are both "complete" and "incomplete" isomorphisms.

A model train differs from a toy train in that the model is isomorphic to a real train. If, in addition to being physically similar to a train, the model works on the same principles as a real train, then the isomorphism is

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10/ *Ibid.*, p. 377.

complete. Extend this idea to theories. If the laws of one theory have the same form as the laws of another theory, then the one is a model of the other. Brodbeck uses an interesting example to make this point:11/

> ...suppose it is wondered whether rumor spreads like diseases. That is, can the laws of epidemiology, about which quite a bit is known, be a model for the theory of rumor transmission? Or, to say the same thing differently, do the laws about rumors have the same form as the laws about diseases? The descriptive concepts in the laws of epidemiology are first of all replaced by letter variables. This reveals the form of the laws. The concepts referring to diseases are put into one-to-one correspondence with those referring to rumors. The letter variables in the epidemiology laws are replaced by the descriptive terms referring to rumors. This results in a set of hypotheses about rumors, which may or may not be confirmed. If, optimistically, these laws are confirmed, then the two theories have the same form.

The definition advocated by Brodbeck is quite rigorous and may be restrictive of research in administration. It is possible to broaden the definition somewhat and still maintain sufficient clarity and rigorousness.

Tyler has suggested a definition of model which, while being much looser, appears to meet the need in administrative research:12/

> ...when an area about which we already know a good deal is used to suggest laws for an area about which little is known, then the familiar area providing the form of the laws may be called a model for the new area.

This type of model only suggests the laws of the new domain being explored. Laws cannot be deduced either logically or mathematically from models of this sort. This does not mean, however, that such models are not useful tools. An illustration used by Szasz demonstrates the value of the suggestive model:13/

11/ Ibid., p. 379.

12/ Ralph W. Tyler, "The Contributions of the Behavior Sciences to Educational Research" in Frank W. Banghart, ed., First Annual Phi Delta Kappa Symposium on Educational Research (Bloomington: Phi Delta Kappa, 1960).

13/ Thomas S. Szasz, Pain and Pleasure (New York: Basic Books, 1957), pp. v, vi.

> ...Simply by comparing the structure or function of a mechanism whose workings are familiar with the structure or functions of another which is less well understood, some degree of mastery usually results. The traditional model of pain is a ringing bell. The noise of the bell, in this metaphor, corresponds to "pain". The model lends itself to the formulation of several relevant questions, such as, "Who pushes the bell?" and "How do we get rid of the noise?"
>
> In a patient with an acutely inflamed appendix, we answer the first question by picturing the diseased organ as "pushing the bell." The proper corrective procedure to eliminate the noise is to remove the appendix.

The Tyler definition is in keeping with the historical use of the term model, but is sufficiently precise and exclusive so as to guide researchers away from some of the dangers encountered in research. As a general rule Brodbeck's definition should be preferred to Tyler's, particularly if the research to be undertaken is to result in a statement of theory. However, there appear to be few theories which can be used as models in administrative research. Since the science of administration is in its infancy, it may well be that it will need to employ cruder methods, as have all other embryonic sciences.

Both definitions warn against a common evil, that is the use of areas or theories concerning which little is known as models for areas about which even less is know.

With this background in simulation and models let us turn to specific models and demonstrate the use of simulation in testing propositions derived from the models. This report contains two models, each developed by the author, which can be used in building theories. A system theory model will be used to develop a theory of change and a decision model will be used to develop a theory of administration. The systems theory model will further be used to explore two areas not related to change.

A Theory of Change

The observer of social organizations is forced to the conclusion that organizations are not characterized by change. Indeed, it would appear that when organizations are viewed over a long period of time their outstanding characteristic appears to be stability rather than change. Social organizations are the structural mechanism employed by societies to achieve certain commonly accepted goals. This being the case, organizations come into existence with a great deal of built-in stability. This stability is so great as to constitute a powerful resistance to change. On the other hand, it is clear that organizations do change; in many, the increments of change are small, in others change is so radical as to cause the disappearance of the original organization and the appearance of a new one.

The Roman Catholic Church is an excellent example of a highly stable organization, existing in the same form over a long period of time. Its organizational goals have varied but little since its inception, yet it has changed. The changes have generally been small, well spaced, and have tended to vary internal procedures or policies necessary to defend itself against an unfriendly environment. On the other hand, the many governmental revolutions illustrate radical changes. The overthrow of the Tsarist regime in Russia and the eventual rule of the Bolshevists points up the fact that an organization (the governing body) can change to the degree that it is completely replaced. It should be noted in both cases, that the stimuli for changes came from outside the organizations. It would not be a far-fetched presumption to state that the members of the Roman Catholic Church and the Tsarist government would have much preferred to go on their merry way.

A theory of administrative change which will, at least in part, account for some of the commonly made observations concerning change in organizations must address itself to these questions:

1. Why is change so infrequent in an organization?
2. Under what conditions does change occur?
3. Under what conditions is change least apt to occur?

Organization and Administration. It is not only conventional, but it is also necessary to say what is meant by organization and administration. First of all only formal organization is being considered and it is construed to mean an ensemble of individuals who perform distinct but interrelated and coordinated functions in order that one or more tasks can be completed. Thus we have the public school, the army, the governmental bureau, the business company, and the like. In each type of organization the task is more or less clearly understood and approved by the public. It is obvious that organizations result in part at least, as a consequence of division of labor in society. It follows that any one organization functions as part of a larger social system.14/

What Kaufman15/ has to say about organizations is also acceptable as contributing to a definition of the concept.

> The term organizations will refer to all sets of human beings who exhibit the following five properties...:
>
> 1. Some criterion or set of criteria by which members may be distinguished from non-members (i.e. Demarcation of boundaries, though not necessarily territorial boundaries);
> 2. Some method of replenishment of materials used up by the members. (Also, for long lived organizations, some methods of replacing personnel lost by the organization through death, departure, disablement, or other factors);
> 3. Elicitation of effort of some kind by individual members of the organization;

14/ Daniel E. Griffiths, Administrative Theory (New York, Appleton-Century-Crofts, 1959), p. 77.

15/ Herbert Kaufman, "Why Organizations Behave as They Do: An Outline of a Theory," in Administrative Theory (Austin: University of Texas, 1961), p 39.

4. Coordination of individual activities - that is to say, some blending of the methods of eliciting effort and the methods of inhibiting activity such that the timing and character of each member's activities facilitate, or at least do not impede, the activities of other members.

5. Some pattern of distribution of materials and messages among the members, and perhaps of movement of people as well.

In summary, a formal organization is a number of people who perform a task sanctioned by the society in which it functions. The members of the organization are visible to the public, work together and have methods of replenishing the organization with both materials and members.

The term administration is used to designate the process (cycle of events) engaged in by all members of the formal organization to direct and control the activities of the members of the organization. Administration occurs whenever the life processes of the organization are being controlled. Those members who are officially charged with the functions of administration are called administrators.[16]

The word change is used to mean an alteration in the structure of the organization or in any of its processes. The revision of a rule, the introduction of a new procedure, or the revision of the purposes or direction of the organization are all subsumed under the concept of change. There can be different degrees of change; a variation in a teacher's luncheon assignment might be considered a minor change and the restructuring of a public school system to include a junior college might be considered a major change.

System-theory

The model employed in building this theory of administrative change is system-theory which is an outgrowth of a relatively new organismic conception as reflected in the work of von Bertalanfy and Goldstein and in certain aspects of Gestalt psychology. It opposes simple reaction theories, where a virtual automation is seen to respond discretely to stimuli.

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[16] Griffiths, op. cit., pp. 72, 73.

A "system" is simply defined as a complex of elements in mutual interaction. System is a construct which has been used in almost every area of science for a long period of time. Floyd Allport offers a more comprehensive definition of system indicating it to be:[17]

> any recognizably delimited aggregate of dynamic elements that are in some way interconnected and interdependent and that continue to operate together according to certain laws and in such a way as to produce some characteristic total effect. A system, in other words, is something that is concerned with some kind of activity and preserves a kind of integration and unity; and a particular system can be recognized as distinct from other systems to which, however, it may be dynamically related. Systems may be complex; they may be made up of interdependent sub-systems, each of which, though less autonomous than the entire aggregate, is nevertheless, fairly distinguishable in operation.

A more succinct definition is that of Hall and Fagen, "A system is a set of objects together with relationships between the objects and between their attributes."[18] This means that a system is composed of objects which are the parts of the system; and that there are relationships among the objects and their attributes which tie the system together. Systems may be open or closed. An open system is related to and exchanges matter with its environment while a closed system is not and does not. Further, a closed system is characterized by an increase in entropy while open systems may tend toward the steady state. All systems except the smallest have sub-systems and all but the largest have supra-systems which are their environments.

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[17] Floyd H. Allport, Theories of Perception and the Concept of Structure (New York: John Wiley and Sons, 1955), p. 469.

[18] A. D. Hall and R. E. Fagen in General Systems - Yearbook of the Society for the Advancement of General Systems Theory, Ludwig von Bertalanfy and Anatol Rapoport, eds. (Ann Arbor: Braun-Brumfield, 1956), p. 18.

Properties of organismic, open systems -- Open systems, of course, have the properties of systems in general, but open systems have certain characteristics which distinguish them from closed systems.[19]

1. Open systems exchange energy and information with their environment; that is, they have inputs and outputs.
2. Open systems tend to maintain themselves in steady states. A steady state is characterized by a constant ratio being maintained among the components of the system. A burning candle is often used as an example of a steady state. Upon being lighted the flame is small, but rapidly grows to its normal size and maintains the size as long as the candle and its environment exist.
3. Open systems are self-regulating. In the illustration above, a sudden draft will cause the flame to flicker, but with the cessation of the draft the flame regains its normal characteristics.
4. Open systems display equifinality; that is, identical results can be obtained from different initial conditions. An example of equifinality is the prematurely born child who, in spite of a shortened pre-natal period attains the same state of maturity as does a child born after a normal pre-natal period.
5. Open systems maintain their steady states, in part, through the dynamic interplay of sub systems operating as functional processes. This means that the various parts of the system function without persistent conflicts which can neither be resolved nor regulated.
6. Open systems can maintain their steady states through feedback processes.
7. Open systems display progressive segregation.[20] This process occurs when the system divides into a hierarchical order of subordinate systems which gain a certain independence of each other.

Hearn summarizes the properties of open, organismic systems in this manner:[21]

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[19] Adapted from Gordon Hearn, Theory Building in Social Work (Toronto: University of Toronto Press, 1958), pp. 44-50.

[20] Ludwig von Bertalanfy, "An Outline of General Systems Theory," British Journal for the Philosophy of Science, Vol. 1, 1950, p. 148.

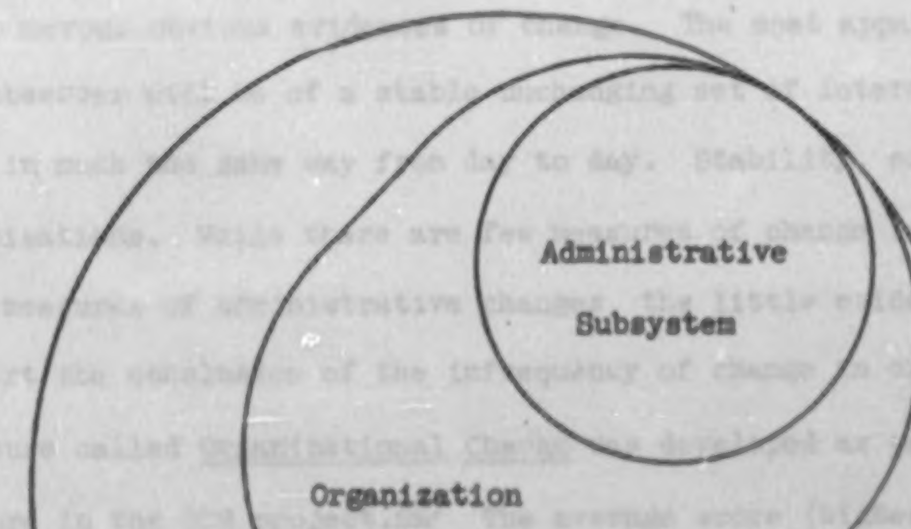
[21] Hearn, op. cit., pp. 48, 49.

> There is a dynamic interplay among the essential functional sub-processes or sub-systems in the organismic system which enables it to maintain itself in a homeostatis steady state. Assuming a sufficient input of material from its environment, the organism develops toward a characteristic state despite initial conditions (equifinality). All of this is accomplished through an automatic self-regulatory process.

A Proposed Theory of Administrative Change

It is proposed that system theory serve as a model for a theory of administrative change. As indicated above any system has supra systems and subsystems, but all this means is that there are related systems of different sizes. Let an organization be considered as a system comprised of human interactions which maintains a definite boundary. Further, consider administration as a subsystem, and the environment as a supersystem. The administrative subsystem is located at the point of tangency of the three systems as in Figure 5.

Figure 5



Infrequency of Change

The above model for a theory of administrative change would lead one to hypothesize that change would be relatively infrequent. Open systems maintain themselves in steady states, that is, by a constant ratio being maintained among the components of the system. Change calls for the establishment of new ratios among the components of the system. One could argue on purely logical grounds that society establishes organizations, or sanctions the establishment of organizations, to accomplish rather specific purposes. It is probably this that gives to organizations their characteristic steady state.

The first proposition offered is a restatement of the concept of the steady state in relation to organizational change.

Proposition 1. Organizations are characterized by stability rather than change.

Discussion - One should not approach the study of organizations anticipating that he will find numerous obvious evidences of change. The most apparent perception of the observer will be of a stable unchanging set of interactions. People will behave in much the same way from day to day. Stability, not change, characterizes organizations. While there are few measures of change in organizations and fewer measures of administrative changes, the little evidence available tends to support the conclusion of the infrequency of change in organizations. For example, a measure called Organizational Change was developed as part of the scoring procedure in the DCS project.[22] The average score (highest possible, 70) was 5.88, standard deviation, 2.92 and odd-even reliability, .61. The observer, if he wishes to study change, must reconcile himself to the study of the infrequent, not the frequent in organizational life.

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[22] John Hemphill, Daniel Griffiths, Norman Frederiksen, Administrative Performance and Personality (New York: Teachers College Bureau of Publications), 1962. Chapter VIII.

Conditions Aiding and Impeding Change

Although infrequent, change does occur, and at times the change is radical in nature. Under what conditions might change be expected to occur? What are the conditions which expedite change? What are the conditions which inhibit change?

Several characteristics of open systems were discussed in the presentation of the model. Some of these have relevance for this section of the paper; input-output, steady state, self-regulation, interplay of subsystems, feedback, and progressive segregation. An examination of these characteristics leads one to the statement of several propositions which are grouped below in two categories; expeditors of change and inhibitors of change.

Edpeditors of Change

Since the tendency for organizations is to maintain a steady state the major impetus for change comes from outside rather than inside an organization. Since organizations are open systems they have a self-regulating characteristic which causes them to revert to the original state following a minor change to accommodate the demands of the suprasystem.

Many organizations bring in outsiders as administrators believing that change for the better will result. This apparently works in many cases and the proposed theory can accommodate this observation. All organizations exhibit some form of progressive segregation or hierarchial order. The order makes it possible for change to occur from the top down and practically impossible from the bottom up.

These ideas are now formulated as a series of propositions.

Proposition 2. The major impetus for change in organizations is from the outside.

Discussion. It is speculated that when change in an organization does occur, the initiative for the change is from outside the system; that is, the suprasystem. In the DCS study it was found that those who were high on the Organizational Change score were not aggressive leaders as much as they were administrators with a tendency to make changes in the organization as required to please outsiders and superiors or in compliance with suggestions of subordinates.[23] The correlations with outsiders are somewhat higher than correlations with subordinates. A study needs to be made of the nature of changes made in response to outsiders and insiders. It is hypothesized that changes made in response to insiders are concerned with clarification of rules and internal procedures while those made in response to outsiders will be concerned with new rules and procedures and possibly with changes in purpose and direction of the organization.

Proposition 3. Most changes initiated by the suprasystem will be of short time duration and little effect.

Discussion. Organizations respond as do self-regulating open systems, that is demand for change often brings the change, but when the demand decreases, whatever has changed will revert to its original state. Thus in the public schools and governmental bureaus, to mention just two types of organizations, it is noted that instant reaction to criticism is followed by some change. The change, however, is followed by a reversion to former practice when the criticism slackens.

Proposition 4. The degree and duration of change is directly proportional to the intensity of the stimulus from the suprasystem.

Discussion. While the precise concepts needed to express this proposition are not available to the author the idea seems to be clear. As an illustration of the proposition (but not, of course, as proof) it is noted that within 15 months of the launching of the Soviet Sputnik I the rate of instructional innovation in New York State public elementary and secondary schools more than doubled and the increase was maintained through 1961.[24]

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[23] Loc. cit.

In order that this proposition be tested it will be necessary to establish ways of measuring degree of change and intensity of stimuli. Duration is simply a matter of time. If the suggested measurements could be made, the proposition could be tested in all of its ramification.

Proposition 5. Change in an organization is more probable if the successor to the chief administrator is from outside the organization than if he is from inside the organization.

Discussion. Referring again to the model, it is noted that feedback is a characteristic of open systems. Feedback tends to maintain the system in a steady state. The administrator from outside does not receive feedback from his actions since channels for feedback to him do not exist. When an insider is appointed to the top post in an organization the feedback channels which have been established over the years function to keep him operating in the steady state.

An outsider may bring change into an organization out of sheer ignorance. Not knowing the system he will function in terms of a system which he does know. Being without ties in the system he will not receive the feedback which would keep an insider from initiating procedures and policies which differ from those in use.

The insider will also keep the subsystems functioning without conflicts since he knows how these subsystems function to maintain the steady state. The outsider may upset the functioning of the subsystems either through ignorance or design. Not knowing how subsystems function he can throw them inadvertently in conflict through orders or expectations not customarily held for these systems. On the other hand, he may introduce conflict among the subsystems by purposefully changing their functions. This will, of course, upset the steady state and may in time create a state more to the liking of the chief administrator. The notion of controlled conflict as a method of change in an organization may have a sound theoretical base.

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[24] Henry M. Brickell, Commissioner's 1961 Catalog of Educational Change (Albany, New York: State Education Department),1961, p. 27.

In a study of school superintendents Carlson found that those appointed from inside the system tend to act in such a way as to maintain the system, while those appointed from outside tend to be innovators.[25] This tends to support the proposition.

Proposition 6. The number of innovations is inversely proportional to the length of tenure of the chief administrator.

Discussion. The longer an administrator stays in a position the less likely he is to introduce change. The model indicates some reasons for this. All of the processes which bring about the steady state have been given time to operate. Feedback channels have become fully established. Progressive segregation has set in to the extent that the subsystems have become structured and have gained relative independence. When subsystems gain independence, change is more difficult because the frequency of interaction is decreased and the chances for effective communication are diminished.

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[25] Richard O. Carlson, "Succession and Performance Among School Superintendents," Administrative Science Quarterly, Vol. 6, No. 2, September 1961, pp. 210-227.

Inhibitors of Change

Many of the characteristics of organizations are such that they make the initiation of change difficult. When organizations are viewed in terms of the systems theory model these characteristics appear very clearly.

Proposition 7. The more hierarchical the structure of an organization the less the possibility of change.

Discussion. The systems theory model points out that a characteristic of open systems is progressive segregation and this occurs as the system divides into a hierarchial order of subordinate systems which gain a degree of independence from each other. The more hierarchical the subsystems become the more independent the subsystems and the more difficult it is to introduce change.

Proposition 8. When change in an organization does occur it will tend to occur from the top down, not from the bottom up.

Discussion. Using the same reasoning as in Proposition 7, a hierarchial order would enable change to occur from the top down, but the relative independence of the subsystems would tend to slow down the rate of change. The structure makes change from bottom up very difficult and one would expect little if any change introduced into an organization from the bottom up.

Proposition 9. The more functional the dynamic interplay of subsystems the less the change in an organization.

Discussion. As the system functions, the subsystems develop method of interacting which tend to minimize conflicts. This becomes the accepted modus operandi. The introduction of change is synonymous with the introduction of conflict among the subsystems. This means that the normal methods, the habits if you will, of the organization tend to be the opposite of innovation.

Using systems theory as a model this section attempts to develop a set of propositions concerning change in an organization. The propositions would lead one to believe that change is not one of the more apparent characteristics of an organization. Organizations are sanctioned by the society because the organizations fulfill certain needs and accomplish certain specified purposes. Organizations maintain a steady state and demonstrate other characteristics of open organismic systems.

Change in organizations will be expedited by the appointment of outsiders rather than insiders as chief administrators. They will introduce change either because they do not know the system or because they have a different concept of how the system should function. This difference has not been researched. Most changes will be the result of a response to the demands of the suprasystem, but will be of short duration. The magnitude and duration of change is directly proportional to the intensity of the stimulus from outside. The number of administrator initiated innovations can be expected to decrease as his tenure increases.

The very nature of the organization (its tendency towards a steady state, self-regulation, feedback, hierarchy, and the subsystems operating as functional processes) impede change.

An Extension of the System-Theory Model

If we keep the same model as the one developed for a theory of change we find it useful in deriving two hypotheses of a general nature; one on decision making, the other on stress.

A question of major importance is, "By what means is the steady state of the administrative system maintained?" The structure of the system, its location as tangential to other systems, the nature of the input and output would lead one to believe that the system tends to avoid extreme positions and to prefer to maintain a relatively even keel. This leads to proposition 10.

Proposition 10. The steady state of the administrative performance system is maintained by a decision process in which satisfactory alternatives are selected rather than optimal alternatives.

Discussion. Simon has suggested that administrative man satisfices rather than maximizes. As he has said,[26]

> 1. While economic man maximizes--selects the best alternatives from among all those available to him; his cousin, whom we shall call administrative man, satisfices--looks for a course of action that is satisfactory or "good enough." Examples of satisficing criteria that are familiar enough to businessmen, if unfamiliar to most economists, are "share of the market," "adequate profit," "fair price."
>
> 2. Economic man deals with the "real world" in all its complexity. Administrative man recognizes that the world he perceives is a drastically simplified model of the buzzing, blooming confusion that constitutes the real world. He is content with this gross simplification because he believes that the real world is mostly empty--that most of the facts of the real world have no great relevance to any particular situation he is facing, and that most significant chains of causes and consequences are short and simple. Hence, he is content to leave out of account those aspects of reality--and that means most aspects--that are substantially irrelevant at a given time. He makes his choices using a simple picture of the situation that takes into account just a few of the factors that he regards as most relevant and crucial.
>
> What is the significance of these two characteristics of administrative man? First, because he satisfices, rather than maximizes, administrative man can make his choices without first examining all possible behavior alternatives and without ascertaining that these are in fact all the alternatives. Second, because he treats the world as rather "empty," and ignores the interrelatedness of all things (so stupefying to thought and action), administrative man is able to make his decisions with relatively simple rules of thumb that do not make impossible demands upon his capacity for thought.

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[26] Herbert Simon, Administrative Behavior (New York: Macmillan, 1957), pp. xxv-xxvi.

Simon regards this explanation of administrative decision-making as verified both by common sense reasoning and through work with machine simulated thought processes.[27]

Several of the scoring categories are related to the choice of alternatives. Such categories as Following Leads by Superiors and Subordinates, Making Concluding Decisions, and Taking Terminal Action could be considered as indicating that the principals restricted their world to their immediate associates and made decisions in terms of what they learned from them. Such categories as Conceptual Analysis and Uses Program Values could be considered as indicating that the principals attempted to analyze the item, to see its broad implications, and to relate the item to background information or to other items. The former was much more prevalent than the latter.

It would appear that the steady state of the administrative performance system is one in which there is more satisficing than maximizing.

Proposition 11. Administrative systems respond to continuously increasing stress first by a lag in response, then by an over-compensating response, and finally by a catastrophic collapse of the system.[28]

Discussion. There is some evidence which indicates that moderate stress lifts performance above ordinary levels, but that extreme stress may cause performance to deteriorate. In the DCS study, for instance, the subjects indicated that, during the test week, they were under more stress than usual, but that they produced more than normally. The intriguing question is, "How much stress can the administrative performance system take before it collapses?" Another way of putting the question is, "What is the optimum stress which should be placed on a system so as to produce optimum performance?" There is no evidence on this at present, but a rigorous testing of this proposition would provide extremely important information.

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[27] *Ibid*., pp. xxvi-xxviii.

[28] James G. Miller, "Toward a General Theory for the Behavioral Sciences," *American Psychologist*, Vol. 10, 1955, p. 525.

A Decision Model

There has been considerable interest in a theory of administration based upon decision making. The author has summarized this interest and noted the promise which it holds.[29] As yet however, there is little empirical evidence to support such a theory. The factor analysis of the DCS project is the strongest evidence to date, but it did not provide specific testing of decision theory propositions.[30] The next few pages presents in summary form a decision theory of administration with several propositions.[31]

The assumptions upon which a decision theory is based are:

1) Administration is a generalized type of behavior to be found in all human organizations.

Administration is a term used to describe an aspect of life in a social organization. Since there is no aspect of living unrelated to a social organization, administration is an integral part of all human life. A logical deduction from this assumption is that the varieties of administration are more alike than different.

2) Administration is the process of directing and controlling life in a social organization.

This assumption means that administration is the implementation of the purposes for which an organization is designed through such procedures as establishing criteria for the performance of individuals as they live in the organization and establishing controls to make certain that performance agrees with plans. Administration is not an artificial function superimposed on the normal activities of human beings; it is rather the process (cycle of events) engaged in by the members of a social organization in order to control and direct the activities of the members within the organization. Administration occurs whenever the life processes of an organization are being controlled. In contrast to this, it can be said that administration is not the production of the organization. Barnard indicated this quite clearly when he said, "Executive work is not that *of* the organization, but the specialized work of *maintaining* the organization in operation.[32] This leads to the next assumption.

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[29] Griffiths, Administrative Theory, op. cit.

[30] Hemphill et al. Chapter XIII.

[31] Griffiths, op. cit. Chapter IV.

> 3) The specific function of administration is to develop and regulate the decision-making process in the most effective manner possible.

It is sometimes assumed that the function of the chief executive officer is to make decisions, generally by himself because others are incompetent. This is not the basic assumption of this theory, rather it is the assumption that it is the function of the executive to see to it that the decision process proceeds in an effective manner. (An effective manner is one which results in the accomplishment of a stated objective.) In fact, the executive is called upon to make decisions only when the organization fails to make its own decisions. To put this into other words, if the executive is personally making decisions this means that there exists malfunctioning in the decision process. The executive then needs to correct the malfunctioning. Barnard was referring to this point when he said:[33]

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[32] Chester I. Barnard, *The Functions of the Executive* (Cambridge, Mass. Harvard University Press, 1938), p. 215.

[33] *Ibid.*, p. 211.

> "It is the organization, not the executive, which does the work on the external environment. The executive is primarily concerned with decisions which facilitate or hinder in the effective or efficient operation of the organization."

4) The behavior of an administrator can be described using concepts normally employed in describing the decision-making process.

A number of propositions follow from these assumptions:

Proposition 1. The structure of an organization is determined by the nature of its decision-making process. The issues of organizational structure such as "span of control" can be resolved if viewed as the outgrowth of a particular type of decision-making process.

Proposition 2. An individual's rank in an organizational structure is directly related to the degree of control he exerts over the decision process. Another way of saying this is that the individual who makes the decisions which establish the criteria by which others make decisions has highest rank in an organization.

Proposition 3. The effectiveness of a chief executive is inversely proportional to the number of decisions which he must personally make concerning the affairs of the organization. It is not the function of the chief executive to make decisions; it is his function to monitor the decision-making process to make certain that it performs at the optimum level.

This proposition may be expressed mathematically as follows:

$$E\ (t) = \frac{1}{D\ (t)}$$

In this formula $\underline{E}$ is effectiveness in achieving the stated objectives of the organization; $\underline{t}$ is a specific time interval; and $\underline{D}$ is the sum total of the number of decisions made in $\underline{t}$, the specific time interval.

Proposition 4. Differences in the organizational structure of military, industrial, educational, business, and public administration institutions are related to differences in decision-making processes rather than such conventional concepts as private enterprise.

Proposition 5. If the formal and informal organization approach congruency, then the total organization will approach maximum achievement. By "approaching congruency" is meant that the formal and informal organizations must perceive the task of the organization as being the same for both, and both must behave in much the same way to carry out the task. In all probability congruency could never be attained; in fact, it would be undesirable if it ever were attained since there would then exist a state of balance in which there would be no progress.

Proposition 6. If the total organization is not approaching maximum achievement, then, in all probability, the formal and informal organizations are divergent. This proposition suggests that the major reason for failure to achieve at a maximum level is the divergency of perceptions and resultant behaviors between the formal and informal organizations.

Proposition 7. There exists an optimum divergency between the formal and informal structures. This proposition suggests that in organizations which produce at a maximum level there is a difference in how each structure perceives the task of the total organization and in resultant behavior. In other words, the two cannot be so far apart in their perceptions as to be striving for different goals, nor so close together that there is no conflict in perception.

Proposition 8. If there is no conflict between formal and informal structures in the perception of the task of the organization, the organization will not achieve at a maximum level. This proposition takes into account the fact that both structures exist to achieve legitimate purposes for their members and that, if the task is perceived without conflict, the purposes of the two structures are imperfectly formulated.

Proposition 9. If the administrator confines his behavior to making decisions on the decision-making process rather than making terminal decisions for the organization, his behavior will be more acceptable to his subordinates.

Proposition 10. If the administrator perceives himself as the controller of the decision-making process, rather than the maker of the organization's decisions, the decisions will be more effective.

The question now is, What type of simulation will lend itself to testing the large number of propositions generated by the two theories? The answer is really not known, yet an approach can be suggested always keeping in mind the fact that in any research the technique can be modified as difficulties become obvious.

Simulation to Test Models

It is proposed that a simulation be built to test the models developed in the preceeding section. Several propositions were stated, each of which can be tested in a simulated situation.

A simulation should be built around a city school district, one of about 20,000 pupil population. A district of this size might have two senior high schools, three junior high schools, and 15 elementary schools. Background information could be compiled in an appropriate format. This might take the form of films, recordings, and documents. While the information would not need to be elaborate, it should be copious enough so that the subjects would feel comfortable in dealing with incidents that would occur in the simulated school district and community.

In this simulation the subjects should be allowed to group themselves into administrative teams of six or seven members. One subject would be designated superintendent, another assistant superintendent for business affairs, etc., until a central office team had been built. A number of items would be built, some on the same principle as the in-basket, others on continuing problems such as bond issues or curriculum revisions. Rather than confronting the team as a whole with the items, they would be given to each member in a realistic fashion. For example, the superintendent would receive items from the board of education, the assistant superintendent for business would receive complaints about building maintenance, and the curriculum coordinator would receive reports on teaching problems. The items would be fed in as they are in a real school.

Once action had been taken there would be a computee feedback. This is probably the most difficult technical problem in the study, but is not insurmountable. The computee would be programmed with feedback information for each response. The feedback would be developed by a jury of experts in each area of problems. For example, business problems would be serviced by a group of business experts. They would take possible responses and program what to them would be the probable consequences of the action. This would be fed back to the appropriate member of the team and might be handled as another item.

The time sequences would be telescoped so that in a week of actual time, for instance, it would be possible to have 20 years of simulated school time. The change propositions could be tested in this manner.

A simulation of the type presented above would be difficult to build, but would not be impossible. Needless to say a start should be made on it immediately.

Appendix A

SELECTED ANNOTATED BIBLIOGRAPHY OF MODELS

As one studies the research methodology in educational administration he is struck by the paucity of theory and with the limited number of approaches employed by researchers. In order to suggest new approaches a comprehensive search of the social science and related literature was undertaken. This has resulted in a bibliography of models that have been used to study behavior. The references have been categorized under the following heads:

- Biophysics, Mathematical
- Business
- Education
- Mathematics
- Philosophy of Science
- Psychology
- Social Sciences (general)

A complete bibliographical reference is given together with a description of the author's work. Occasionally the reader is merely encouraged to read the whole article, but generally the annotation is intended to give the gist of work being reported. Charles R. Kelley graduate student at Teachers College, Columbia University, performed the literature search.

Biophysics, Mathematical

Householder, Alton S. and Landahl, Herbert D. Mathematical Biophysics of the Central Nervous System (Bloomington, Ind., Principia Press, 1945).

> The authors state that they are seeking to develop a theory of the nervous system as the determiner of behavior.... The task of developing this theory is three-fold. First, an idealized model of the elementary units must be constructed in terms of postulates governing their individual behavior and their individual behavior and their interactions. The model must be simple enough to permit conceptual manipulation.... "We wish, therefore, to define our schematic reacting organism as one consisting solely of receptors (sense-organs), effectors (muscles), and a connecting set of neutrons, the whole and the parts being affected by the physical or physiological environment only in so far as this acts as a stimulus via the receptors. We wish to consider to what extent behavior can be accounted for in terms of such a model." The book is developed on this premise.

Rashevsky, Nicolas, Mathematical Biology of Social Behavior, rev. ed. (Chicago, University of Chicago Press, 1959).

This book is an attempt to use mathematical formulations to interpret behavior. Rashevsky is in the forefront of the effort to develop a mathematical theory of human behavior. He has written to this end in his books prior to this one, namely:

1) Mathematical Biophysics
2) Mathematical Theory of Human Relations

This book has mathematical formulations to interpret human behavior in these areas:

Part I - Brain Mechanism and Behavior
II - Social Hierarchies
III - Imitative Behavior
IV - Motivational Behavior (etc.)

The book, although requiring basic calculus only, is difficult to understand.

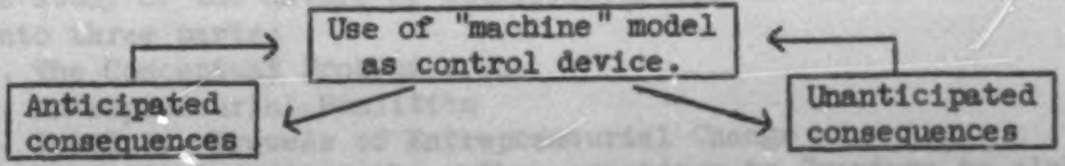
Business

Davies, Daniel R. and Livingston, Robert T., You and Management (New York, Harper, 1958).

In this book a "job model" and a "man model" are presented in the authors' effort to specify what managers do and what managers are like. While these are not models in any strict sense of the word, they do offer ways of ordering information about man and the job.

March, James G. and Simon, Herbert A., Organizations (New York, John Wiley and Sons, 1958).

This book presents a number of models. An example follows: On p. 37 is presented the Merton model of bureaucracy.


Use of "machine" model as control device.
Anticipated consequences
Unanticipated consequences

Merton is concerned with dysfunctional organizational learning: organization members generalize a response from situations where the response is appropriate to similar situations where it results in consequences unanticipated or undesired by the organization.

Consequences:

1) reduction in amount of personalized relationships
2) internalization of the rules of the organization
3) use of categorizations as a decision-making technique.

This book is probably the most useful reference in the field of organization at the present time.

Rubenstein, Albert H. and Haberstroh, Chadwick J., eds., Some Theories of Organization (Homewood, Ill., Dorsey Press and Irwin, 1960).

p. 7. "Is a Model a Theory?
A model is a system or object that stands in place of another usually more complicated system or object. Simple examples are an architect's scale model for a building, or the company telephone directory as a model of the organization. A mathematical model is similar. The difficulty that arises is that the mathematical model is likely to be confused with a mathematical theory. The reason for this confusion is the similarity of appearance: both use premises and deduce conclusions in a mathematical manner. To the philosophically unsophisticated, one page full of symbolism looks about the same as another. The differences in the two systems, however, partly determine the uses to which they can be put.

The logical structure of a theory is such that the conclusions derived from it can be placed in correspondence with (interpreted as) empirical hypotheses and confirmed or refuted by experiments. The logical structure of a model is such that its premises are interpreted (i.e., empirical statements) and its conclusions are logical consequences of these. A theory can be refuted by a single contrary empirical finding; a model is not exposed to refutation.... A model can continue to be useful even though it yields many conclusions which are clearly wrong, provided only that it yields some conclusions that are correct (i.e., useful). A theory is expected to yield only true conclusions.

... Thus, although models are not theories, they may contribute to theory building."

Cole, Arthur H., Business Enterprise in Its Social Setting (Cambridge, Harvard University Press, 1959).

Book grows out of author's work at Harvard's Research Center in Entrepreneurial History (closed 1958).
In this study of the nature of entrepreneurship the author divides the book into three parts:

1. The Conceptual Problem
2. Entrepreneurial Realities
3. Postlude: Process of Entrepreneurial Change

It is in the Postlude that the author considers to "venture to elaborate a 'model' of the nature of entrepreneurial change." He seeks to construct a model, or models, of entrepreneurial change, setting forth periods or stages by which entrepreneurship evolves from a rather primitive to a rather complicated phenomenon. The model, hopefully, would be of assistance to those currently working in the field of economic development. He lists three elements he would use in constructing an explanation of such change: (1) arrangements between the close and distant forces that affect the entrepreneur; (2) motivation, particularly 'need for recognition of achievement;' (3) political and social atmosphere that may or may not be conducive to entrepreneurial achievement. There is no contention made that the model is operational.

Koopmans, Tjalling, "Identification Problems in Econometric Model Construction," Econometrica, Vol. 17 (1949) pp. 125-144.

Koopmans, Tjalling, ed., Statistical Inference in Dynamic Economic Models, Cowles Commission Research Report (New York, Wiley, 1950).

Lange, Oscar, "The Scope and Method of Economics," in Fiegl, Herbert and Brodbeck, May, eds. Readings in the Philosophy of Science (New York, Appleton-Century-Croft, 1953) pp. 744-754.

In his description of theoretical economics Lange states: "A deductive set of theorems to be subjected to empirical test is also called a theory, hypothesis, or a model... Since the assumptions (postulates) underlying a model are only approximative, the theorems do not correspond directly to results of empirical observations..."
Lange recommends a procedure be established to bridge gap between theoretical concepts and empirical observations. This would be a procedure of identification. He mentions the new field of econometrics which deals with such procedures of verification.

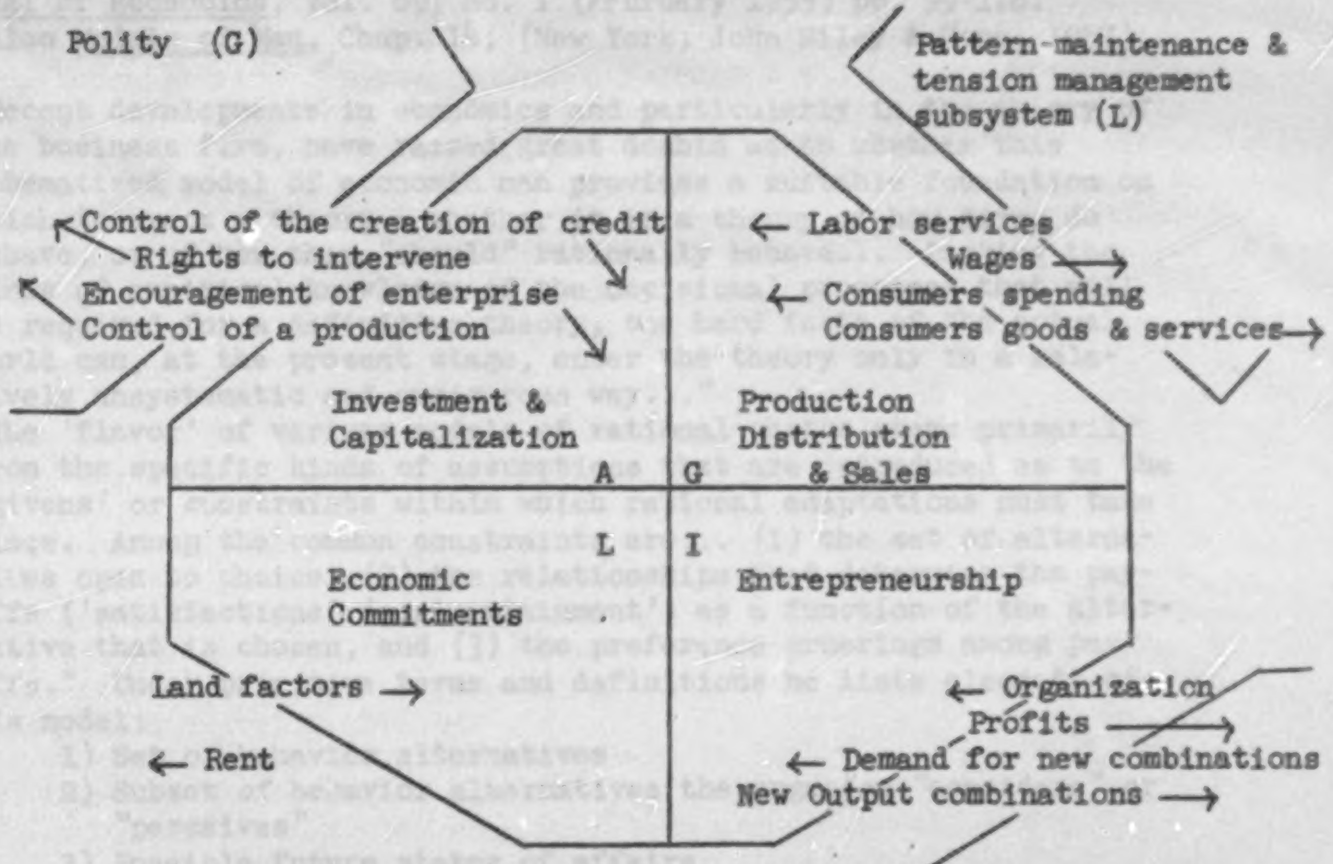
Parsons, Talcott and Smelser, Neil J., "A Sociological Model for Economic Development," Explorations in Entrepreneurial History, Vol. 8, No. 4. (April 1956) pp. 181-204.

The article outlines and illustrates a systematic model of institutional development. The foundation for the model is a developing general theory of action, of which the theory of social systems is a branch. The aim of the model is to outline systematically the major noneconomic relationships among the components of economic development.

"The concept of a social system is an analytical concept used to classify modes of relationship and bases of decision by means of which the concrete units of the social system function as a system... A society in the theoretical or the empirical sense is a network of differentiated subsystems in a very complex relation to one another..."
The process in any social system is subject to four independent functional imperatives:

1) Latent pattern maintenance and tension management. A social system is characterized by an institutionalized value system. The maintenance of this value system is the 1st functional imperative.
2) Goal attainment.
3) Adaptation.
4) Integration ("maintenance of solidarity" of relations among units).

Subsystems of the Economy and the Major Boundary Interchanges


Polity (G)
Pattern-maintenance & tension management subsystem (L)
Control of the creation of credit
Rights to intervene
Encouragement of enterprise
Control of a production
Labor services
Wages
Consumers spending
Consumers goods & services
Investment & Capitalization
Production Distribution & Sales
A
G
L
I
Economic Commitments
Entrepreneurship
Land factors
Rent
Organization
Profits
Demand for new combinations
New Output combinations
Integrative System (I)

A - Adaptive
I - Integrative
G - Goal attainment
L - Pattern maintenance

Central proposition: quantitative changes of sufficient magnitude involve changes in organization and a modification of the structure of the system.

Discusses institutional change - (Standard Oil splitting into regional headquarters, for example); propagation of the impetus to change; and the process of structural differentiation. Considers steps in separation of ownership and management in American economy:

1) Dissatisfaction re maximum productivity, etc.
2) Symptoms of disturbances appeared (technology of Veblen).
3) Permissive-supportive attitudes toward "captains of industry."
4) The "new enterprise" of organizers (U.S. Steel after Morgan-Carnegie).
5) New financial practices (free sale of securities to public).
6) New wave of profits.
7) New position consolidated by routinization.

Feels this model adequately handles the conditions which produce a sequence leading to one type of economic innovation, i.e., change of organization by means of a process of structural differentiation and reintegration.

Simon, Herbert A., "A Behavioral Model of Rational Choice," in Quarterly Journal of Economics, Vol. 69, No. 1 (February 1955) pp. 99-118. See also Models of Man, Chap. 14, (New York, John Wiley & Sons, 1957).

"Recent developments in economics and particularly in the theory of the business firm, have raised great doubts as to whether this schematized model of economic man provides a suitable foundation on which to erect a theory - whether it is a theory of how firms do behave, or of how they "should" rationally behave... Lacking the kinds of empirical knowledge of the decisional processes that will be required for a definitive theory, the hard facts of the actual world can, at the present stage, enter the theory only in a relatively unsystematic and unrigorous way..."
"The 'flavor' of various models of rational choice stems primarily from the specific kinds of assumptions that are introduced as to the 'givens' or constraints within which rational adaptations must take place. Among the common constraints are... (1) the set of alternatives open to choice; (2) the relationships that determine the payoffs ('satisfactions' 'goal attainment') as a function of the alternative that is chosen, and (3) the preference orderings among payoffs." Under primitive terms and definitions he lists elements of his model:

1) Set of behavior alternatives
2) Subset of behavior alternatives the organism "considers" or "perceives"
3) Possible future states of affairs
4) A "pay-off" function
5) Information as to which outcomes in three will actually occur, if particular alternative is chosen.
6) Information as to the probability that a particular outcome will ensue.

This is given a simple mathematical formulation. He outlines a "fairly complete model" and describes one extension of the model into dynamics.

von Neumann, John and Morgenstern, Oskar, Theory of Games and Economic Behavior (Princeton, Princeton University Press, 1953).

This classic includes descriptions of economic and mathematical models. For example: "...when feasible at all - find a mathematical model for the physical domain in question, within which those quantities are defined by numbers, so that in the model the mathematical operation describes the synonymous 'natural' operation."
"...For economic and social problems the games fulfill...the same function which various geometrico-mathematical models have successfully performed in the physical sciences. Such models are theoretical constructs with a precise, exhaustive and not too complicated definition, and they must be similar to reality in those respects which are essential in the investigation in hand...The definition must be precise and exhaustive in order to make a mathematical treatment possible. The construct must not be unduly complicated..."

Education

Coladarci, Arthur P. and Getzels, Jacob W., The Use of Theory in Educational Administration (Stanford, Calif., Stanford University Press, 1955). p. 26.

"What we would argue, again, is that a theoretical formulation in ideal-type terms permits the creation of a criterion against which to assess and understand reality, not, it must be reiterated, that reality will coincide with the model. After all, the physical model of the body in motion continuing in motion does not conform to reality and appears to deny the actuality of friction. Yet no one doubts that such formulation helps us to understand, to predict, and to control in a very practical way the very reality from which it departs."

A presentation is made of role theory as a model for an administrative theory.

Creegan, Robert F., "A Modelistic Educational Theory," School and Society Vol. 87, No. 2164 (December 19, 1959) pp. 511-512.

In a sense this is a rather unfortunate article in that the author has taken the words, "models"; "educational theory" and given them a very esoteric usage. When he gets to the end of his brief article he states: "Our outcome may seem to be abstrusely philosophical, but even the most elementary education is philosophical, and it is time to face up to that inescapable state of affairs."

His statement "abstrusely philosophical" is really a very modest appraisal. By "modelism" he refers to "the first principle" in human learning that constructs or reconstructs models of life and the world. "Modelism opposes the positivistic interpretation of statements concerning values to the effect that they are nothing more than emotional exclamations. Each model of reality includes a perception of problems, and people acclaim as good whatever seems capable of solving or of obviating problems of a painful character."

Since there is no attempt to define what he means by educational theory and "modelistic" is used in a peculiar fashion the article is not very useful to the administrative theoretician.

There is a reply to this article in the correspondence section of School and Society, September 24, 1960 from, Asst. Supt. of St. Paul, Minnesota Schools (Nolan C. Kearney) who states Creegan's article is too abstruse, etc., wonders if there is anything new except terminology.

Getzels, Jacob W., "Administration as a Social Process," in Halpin, Andrew, W. ed. Administrative Theory in Education (Chicago, University of Chicago, 1958) pp. 150-165.

Here is given a full explanation of Getzels' social system model, a number of hypothetical derivations from the model, and reports of research which the model has generated.

Gregg, Russell T., "Administration," in Harris, Chester W., ed., Encyclopedia of Educational Research (New York, Macmillan, 1960) 3rd edition, pp. 19-24.

p. 21. "In more recent years, research in administration has become increasingly conceptual in nature. Halpin has developed a model for

research in administrator behavior which is consistent with the social scientist's conceptions of organization and of leadership. Recent concepts of the relationship of the administrator to such reference groups as the board of education, the staff, and the opinion leaders of the community have been investigated in a large number of studies.... Recent theories in educational administration have already led to productive researches. It may be expected that as more complete theory is formulated in the future increasingly significant research will be stimulated."
(It should be noted here that Gregg uses model as a synonym for paradigm.)

Griffiths, Daniel E., Administrative Theory (New York, Appleton-Century-Crofts, Inc. 1959).

Chapter 2 of this book is devoted to a discussion of the nature of theory and contains a section on models in which they are defined and illustrated. Chapter 3 is devoted to a presentation of eight theories of administration some of which employ models. Chapter 4 presents a theory of administration based upon a decision-making model.

Halpin, Andrew W. "A Paradigm for Research on Administrator Behavior," in Campbell, Roald F. and Gregg, Russell T., eds. Administrative Behavior in Education (New York, Harper, 1957) pp. 155-199.

Halpin presents a paradigm for research on administrator behavior, not as a theory but as one way of thinking about research on administration that may accelerate the development of a useful theory. Halpin refers to his paradigm as a model, but footnotes that the term "model" is used in the sense of a theoretical model or mathematical model and with no connotation of exemplariness. It should be noted that this is a rather loose use of the term model.

McClellan, James E., "Theory in Educational Administration," The School Review, Vol. 68, No. 2 (Summer 1960) pp. 210-227.

About half of this article is devoted to a discussion of appropriate models to be used in building a theory of administration. He feels that decision models have the most potential and that game theory is probably the best of the decision models at the present time.

Morphet, Edgar L., Johns, Roe L., and Reller, Theodore L., Educational Administration (Englewood Cliffs, New Jersey, Prentice-Hall, 1959).

p. 93 - In Chapter 4, "Educational Leadership" the authors discuss "A Model for the Study of Administrative Behavior." They state, "Halpin has proposed a model or paradigm for the study of administrator behavior in education." There is a brief resume presented of Andrew W. Halpin's "A Paradigm for Research on Administrative Behavior" in Administrative Behavior in Education, edited by Campbell and Gregg.

Thompson, James D., "Modern Approaches to Theory in Administration," in Halpin, Andrew W. ed., Administrative Theory in Education, (Chicago, University of Chicago, 1958) pp. 20-39.

p. 35 - "...in the last decade several attempts have been made to formulate administrative theory on the basis of models derived from a number of different sources: learning models, decision-making models, group dynamics models, leadership models, social system models, game models, and so on. Some of these have been more deeply rooted in empirical observation than others; each has started from unique premises. The very proliferation of these models suggests that we are dissatisfied with traditional approaches and are motivated to do something about them. Probably all these models contain some 'truth' although my impression is that they are helpful primarily in broadening the scope of our inquiry..."
Thompson discusses various models now being employed in an attempt to measure the progress of modern approaches to theory. He sums up with: "The ultimate criterion of a scientific theory, of course, is its utility in adding to our understanding. Few of these models can yet claim to have made much of a contribution in this respect, but I think there is reason to believe that they are laying the foundation for an adequate theory."

Mathematics

Cundy, H. Martyn and Rollett, A. P., Mathematical Models (Oxford, Clarendon Press, 1952).

The book opens with: "The human mind can seldom accept completely abstract ideas; they must be derived from, or illustrated by, concrete examples... In theory, any figure drawn on paper is a tangible aid to the understanding, and there would be some justification in including this in the title, for the earliest use of the word 'model' denoted a set of architect's plans...."
The book goes on to describe the materials and usages of models that can be constructed to elucidate the field of mathematics, particularly solid geometry.

Philosophy of Science

Bergmann, Gustav, "The Logic of Quanta," in Feigl, Herbert and Brodbeck, May, eds. Readings in the Philosophy of Science (New York, Appleton-Century-Crofts, 1953) pp. 475-508.

Bergmann alludes briefly to a model theory and a model in this article outlining a technical description of the modern quantum theory.
"I can only say that a model theory is a theory with a partially coordinated mechanical schema - the model - and that the old kinetic theory before Maxwell and Boltzmann is still the best paradigm for it... All one can require of a model is that it is somehow coordinated to the empirical constructs. A model thus coordinated may be redundant in the sense that some of its features are not utilized in the coordinations."

Black, Max, *Language and Philosophy* (Ithaca, N.Y., Cornell University Press, 1949).

In his semantic definition of truth Black offers an illustrative model. It is a highly simplified model dealing with some very obtuse semantic refinements.

Boudi, Hermann, "Astronomy and Cosmology," in Newman, James R., ed., *What Is Science?* (New York, Simon and Schuster, 1955) pp. 63-96.

There is an introductory discussion of the improvement of models by Copernicus, Ptolemy, Kepler, Newton.
He states that "The method of constructing a theoretical Stellar model is straightforward in principle, though the details are mathematically and physically highly complex." He then enumerates the many factors that must be considered in constructing this stellar model.

Braithwaite, Richard Bevan, *Scientific Explanation* (Cambridge, Cambridge University Press, 1955).

In the chapter "Models for Scientific Theories, Their Use and Misuse" the discussion is opened with establishing the *logical* and *epistemological* priority of hypotheses in two deductive systems (based on 2 interpretations of a calculus, one *geometrical*; one *factor*.
Author states: "*A theory and a model for it, or a model and a theory for which it is a model, have the same formal structure, since theory and model are each* represented by the same calculus. There is a one-one correlation between the propositions of the theory and those of the model..."
"But the theory and the model have different epistemological structures... To use again the metaphor of the zip-fastener, the calculus is attached to the theory at the bottom, and the zip fastener moves upwards; the calculus is attached to the model at the top, and the zip-fastener moves downwards."
Author quotes from "Heinrich Hertz, the most philosophically profound of the great nineteenth-century physicists who wrote on the philosophy of science":
"'We make for ourselves internal pictures or symbols of external objects and we make them of such a kind that the necessary consequence in nature of the objects pictured... When on the basis of our accumulated previous experiences we have succeeded in constructing pictures with the desired properties, we can quickly derive by means of them, as by means of models, the consequences which in the external world would only occur in the course of a long period of time or as a result of our own intervention.'"
"The use of models allows of a philosophically unsophisticated approach to an understanding of the structure of a scientific deductive system."
Two dangers in the use of models are cited:

1) Projecting onto theory empirical features of objects of the model
2) Transferring logical necessity of features of model on to the theory.

Bridgman, P. W., *The Logic of Modern Physics* (New York, Macmillan, 1927).

A brief section on Models and Constructs discusses the considerations of constructing a model of the atom in Euclidean space. He

states: "Further we cannot attach any real significance to the statement that the space of the atom is Euclidean unless we can show that no model constructed in non-Euclidean space can reproduce the measurable properties of the atom.
"...In spite of all this I believe that the model is a useful and indeed inescapable tool of thought, in that it enables us to think about the unfamiliar in terms of the familiar."

Brodbeck, May, "The Philosophy of Science and Educational Research," in Review of Educational Research, Vol. 27, No. 5 (December, 1957) pp. 427-440.

Because educational research is part of the less-developed social and psychological sciences the author presents recent analyses by philosophers of science of some more general problems of meaning and explanation in science. Subtopics treated are: Operationism, Causation, Theories, and Models.
It is stated: "...there are two major uses of model. The most general use is as a synonym for theory." The second most general meaning of the term is in its isomorphic usage, where "if the laws of one theory have the same form as the laws of another theory one may be said to be a model for the other." Testing of Models and Arithmetical Models concludes the article.

Church, Alonzo, Introduction to Mathematical Logic (Princeton, New Jersey, Princeton University Press, 1956).

In his exposition of the postulate theory Church introduces the notion of a model of a system of postulates. This is a highly specialized use of the term "model" where postulates used as the basis for some mathematical theory, have to be thought of as added to an underlying logic. This statement is similar to treatment given by Tarski.

Cohen, Morris R. and Nagel, Ernest, An Introduction to Logic and Scientific Method (New York, Harcourt, Brace, 1934).

It is stated that there are 2 kinds of theories: (1) physical, and (2) mathematical or abstractive. Further there are two methods of framing a theory. "In a mathematical or abstractive theory, a class of objects or phenomena is defined by describing the assemblage of properties which is common to all the objects of phenomena composing the class, as perceived by the senses, without introducing anything hypothetical. In a physical theory a class of objects is defined as being constituted, in a manner not apparent to the senses, by a modification of some other class of objects or phenomena whose laws are already known.
"In the second kind of theory, some visualizable model is made the pattern for a mechanism hidden from the senses... Examples of this kind of theory are the atomic theory of chemistry, the kinetic theory of matter as developed in thermodynamics and the behavior of gases, the theory of the gene in studies on heredity, the theory of lines of force in electrostatics, and the recent Bohr model of the atom in spectroscopy."

"In the mathematic type of theory, the appeal to hidden mechanism is eliminated, or at any rate is at a minimum... Examples of such theories are the theory of gravitation, Galileo's law of falling bodies, the theory of the flow of heat, the theory of organic evolution, and the theory of relativity."

Oppenheim, Paul and Putnam, Hillary, "Unity of Science as a Working Hypothesis," in Feigl, Herbert, Scriven, Michael, and Maxwell, Grover, eds. Minnesota Studies in the Philosophy of Science, Vol. II (Minneapolis, University of Minnesota Press, 1958) pp. 3-36.

There is cited the brilliant analysis of desoxyribose nucleic acid (DNA) made by two biologists Crick and Watson based on their model. A description of the model is given.

Sellars, Wilfried, "Empiricism and the Philosophy of Mind," in Feigl, Herbert and Scriven, Michael, eds., Minnesota Studies in the Philosophy of Science, Vol. I (Minneapolis, University of Minnesota Press, 1956) pp. 253-329.

Sellars feels that by speaking of the construction of a theory as the elaboration of a postulate system which is tentatively correlated with observational discourse is highly artificial and an unrealistic picture of how scientists have actually constructed theories. He holds: "That the fundamental assumptions of a theory are usually developed not by constructing uninterpreted calculi which might correlate in the desired manner with observational discousrse, but rather by attempting to find a model, i.e. to describe a domain of familiar objects behaving in familiar ways such that we can see how the phenomena to be explained would arise if they consisted of this sort of thing. The essential thing about a model is that it is accompanied, so to speak, by a commentary which qualifies or limits - but not precisely or in all respects - the analogy between the familiar objects and the entities which are being introduced by the theory." He continues in this vein holding that "science is continuous with common sense, and the ways in which the scientist seeks to explain empirical phenomena are the refinements of the ways in which plain men, however crudely and schematically, have attempted to understand their environment and their fellow men since the dawn of intelligence."

Tarski, Alfred, Introduction to Logic (New York, Oxford University Press, 1949).

In his Chapter VI "On the Deductive Method," Tarski lays down the principles for constructing a discipline known as the deductive method; "and the disciplines constructed in this manner are called deductive theories."
Using these principles he builds a deductive theory from the congruence of lines in geometry. He sets two axioms, deduces two theorems and then replaces the "primitive terms" with suitable variables in all axioms and theorems and establishes a model or a realization of the axiom system. He states that this model of the axiom system of his theory is also referred to as a model of the theory itself.

The next section carries the discussion further in its consideration of the law of deduction and the formal character of the deductive sciences.

Werkmeister, W. H., A Philosophy of Science (New York, Harpers, 1940).

Newton's experimental inquiry of the refrangibility of different rays of light is discussed in some detail as a model of methodological procedure.

Wilson, Joe E. Bright, An Introduction to Scientific Research (New York, McGraw-Hill, 1952).

In two pages Wilson notes that hypotheses are usually constructed on the basis of analogies with other known phenomena. Cites Newlands' "law of octaves" that was forerunner of today's periodic table of the elements.
Even though there has been in recent years a tendency to decry the use of models and to claim that physics, at least, has outgrown them and substituted in their place colorless, abstract mathematical formula, Wilson holds that to set up the equations of quantum mechanics for a given system, a model is just as necessary as ever.
"Most people find concrete models the easiest way to see additional implications of a theory."

Psychology

Allport, Gordon W., "Scientific Models and Human Models," Psychological Review, Vol. 54, No. 4 (July 1947) pp. 182-192.

Allport in this very interestingly amusing article calls into question many of the models traditionally used in psychology - "My objection to the animal paradigm for personality and social psychology is not so much that animals lack culture.... "- and posits : "My thesis is that now if ever we need to test our preferred model for its capacity to yield discoveries that have some sure relevance to moral nature and social skills." He calls into question the kinds of models in use in his field and concludes with some ideas on the kind of model needed - a model that is none the less scientific for being humane.

Atkinson, Richard C., "A Stochastic Model for Rote Serial Learning," Psychometrika, Vol. 22 (1957) pp. 87-96.

Self-explanatory.

________, Richard C., "A Markov Model for Discrimination Learning," Psychometrika, Vol. 23, No. 4 (December 1958) pp. 309-322.

Synopsis: A theory for discrimination learning which incorporates the concept of an observing response is presented. The theory is developed in detail for experimental procedures in which two stimuli are employed and two responses are available to the subject. Applications of the model to cases involving probabilistic and non-probabilistic schedules of reinforcement are considered; some predictions are made and compared with experimental results.

Burke, C. J. and Estes, W. K., "A Component Model for Stimulus Variables in Discrimination Learning," Psychometrika. Vol. 22, (1957) pp. 133-145.

Bush, Robert R. and Mosteller, Frederick, Stochastic Models for Learning (New York, John Wiley, 1955).

The authors state that whereas science is empirical, mathematics studies relationships among empirically undefined quantities. "The bridge between pure mathematics and empirical science is the identification of mathematical constructs with observables. When such identifications are made we shall say that we have a mathematical model of a situation. This book is concerned with such a model." Authors feel that though laboratory investigation is needed, "mathematical analysis may contribute to the development of theory in one of the many fields of psychology-learning." A possible mathematical framework for analyzing data from a variety of experiments on animal and human learning is presented.

Chapter I presents "The Basic Model".

"In the construction of mathematical models there are usually three main steps or levels: (1) the mathematical system, (2) the identifications or coordinating definitions, and (3) the specific applications." The authors then elaborate on these three steps (p. 1) in an effort to distinguish between a mathematical system, a general model, and a specific model.

Step 1: "The empirical phenomena for which one hopes to build a model may suggest an appropriate mathematical system to use as a framework..."

Step 2: "The second step in the development of a mathematical model is to state the general correspondence between elements in the mathematical and empirical phenomena."

Step 3: "...is to make specific applications of the general model to actual situations. These applications might be regarded as specific models. The general model then generates many specific models."

Bush, Robert R. and Estes, William K., eds., Studies for Mathematical Learning Theory (Stanford, Stanford University Press, 1959).

This book is an outgrowth of 1957 Ford Foundation-sponsored Stanford Summer Institute on the Applications of Mathematics in Social Science Research and is a collection of twenty Institute papers, divided into three parts:

Part I Stimulus Sampling Models (7 papers)
Part II Analyses of Linear Models (7 papers)
Part III Extensions and Comparisons (6 papers)

Every paper is concerned with a model or models. Book follows two main lines of inquiry: (1) the development of a model of the stimulus environment of an experimental subject and with the processes by which that environment influences behavior; and (2) concerned with models of time sequence of responses and with the detailed properties of the stochastic processes defined by those models.

Bush, Robert R. and Mosteller, Frederick, "A Mathematical Model for Simple Learning," Psychological Review, Vol. 58, No. 5 (September, 1951) pp. 313-323.

A mathematical model for simple learning is presented. Changes in the probability of occurrence of a response in a small time are described with the aid of mathematical operators. The parameters which appear in the operator equations are related to experimental variables such as the amount of reward and work. Acquisition and extinction of behavior habits are discussed. An attempt is made to analyze the learning process with various schedules of partial reinforcement.

Bush, Robert R. and Mosteller, Frederick, "A Model for Stimulus Generalization and Discrimination," *Psychological Review*, Vol. 58, No. 6 (November, 1951) pp. 413-423.

The paper describes "a model, based upon elementary concepts of mathematical set theory. This model provides one possible framework for analyzing problems in stimulus generalization and discrimination." It is further shown how this model generates the basic postulates of their previous work (described above) on acquisition and extinction, where the stimulus situation as defined by the experimenter was assumed constant.

Cronbach, Lee J. and Merwin, Jack C., "A Model for Studying the Validity of Multiple Choice Items," *Educational and Psychological Measurement*, Vol. 15, No. 4 (Winter, 1955), pp. 337-352.

"We describe here a mathematical model... Principles derived from the model will ultimately provide a basis for constructing more valid tests. The model also permits comparison of several proposed modifications of the best answer technique...our model is capable of eventual extension to permit a theoretical comparison of choice items with forced response... and choice with unforced responses..."
There follows the description, with illustrative graphs and data charts, of the model in statistical operation. This model can be used under any of three conditions--it is designed with both theoretical and practical ends in mind. (The computation requires use of electronic computers, as is noted in the Michael article).

Edwards, Ward, "The Theory of Decision Making," *Psychological Bulletin*, Vol. 51, No. 4 (July, 1954) pp. 380-417.

This excellent article reviews literature on theory of decision-making that has been taking place, primarily in economics and psychology. It includes a complete bibliography of decision literature since 1930.
Some illustrations of Edwards' work includes a discussion of the first experiment to apply the von Neumann-Morgenstern model which Mosteller and Nogee carried out with Harvard undergrads and National Guardsmen in a game with bets stated in terms of rolls at poker dice, which each subject could accept or refuse.

English, Horace B. and English, Ava Champner, *A Comprehensive Dictionary of Psychological and Psychoanalytic Terms* (New York, Longmans, Green, 1958) p. 326.

Four definitions of model are given on p. 326.
p. 27 - *analogue*: n.1 (biol.) an organ that is similar in function or in superficial appearance to another but not in origin or basic structure. 2. (logic) that which resembles some other specific item.
p. 368- *paradigm*: n. a model, pattern, or example that exhibits all the variable forms of something: e.g., the pattern showing all the grammatical forms of a word.

Estes, W. K. and Burke, C. J., "Application of a Statistical Model to Simple Discrimination Learning in Human Subjects," Journal of Experimental Psychology, Vol. 50, No. 2 (August 1955) pp. 81-88.

Herein is described in exact detail a series of experiments on simple human learning under random reinforcement which have been interpreted with considerable success in terms of a theory which incorporates a statistical model of the stimulus situation and contiguity assumptions concerning the learning process.
The methodology employed in the experiments is given as well as schematic representations.

Green, Jr., Bert F., "A General Solution for the Latent Class Model of Latent Structure Analysis," Psychometrika, Vol. 16, No. 2 (June 1951) pp. 151-166.

Article considers Lazarsfeld's important contribution to the theory of attitude measurement. "Latent structure, as this innovation is called, is essentially a mathematical model for describing the interrelationships of items in an attitude questionnaire." Article discusses how there are actually two models involved: (1) underlying attitude and item distributions are assumed to be continuous; the other (2) in which the underlying attitude is assumed to have a point distribution. For model (2) the general matrix equation is stated which relates the manifest data in the form of joint occurrence matrices to the latent parameters. An extensive solution for the latent parameters is then presented.

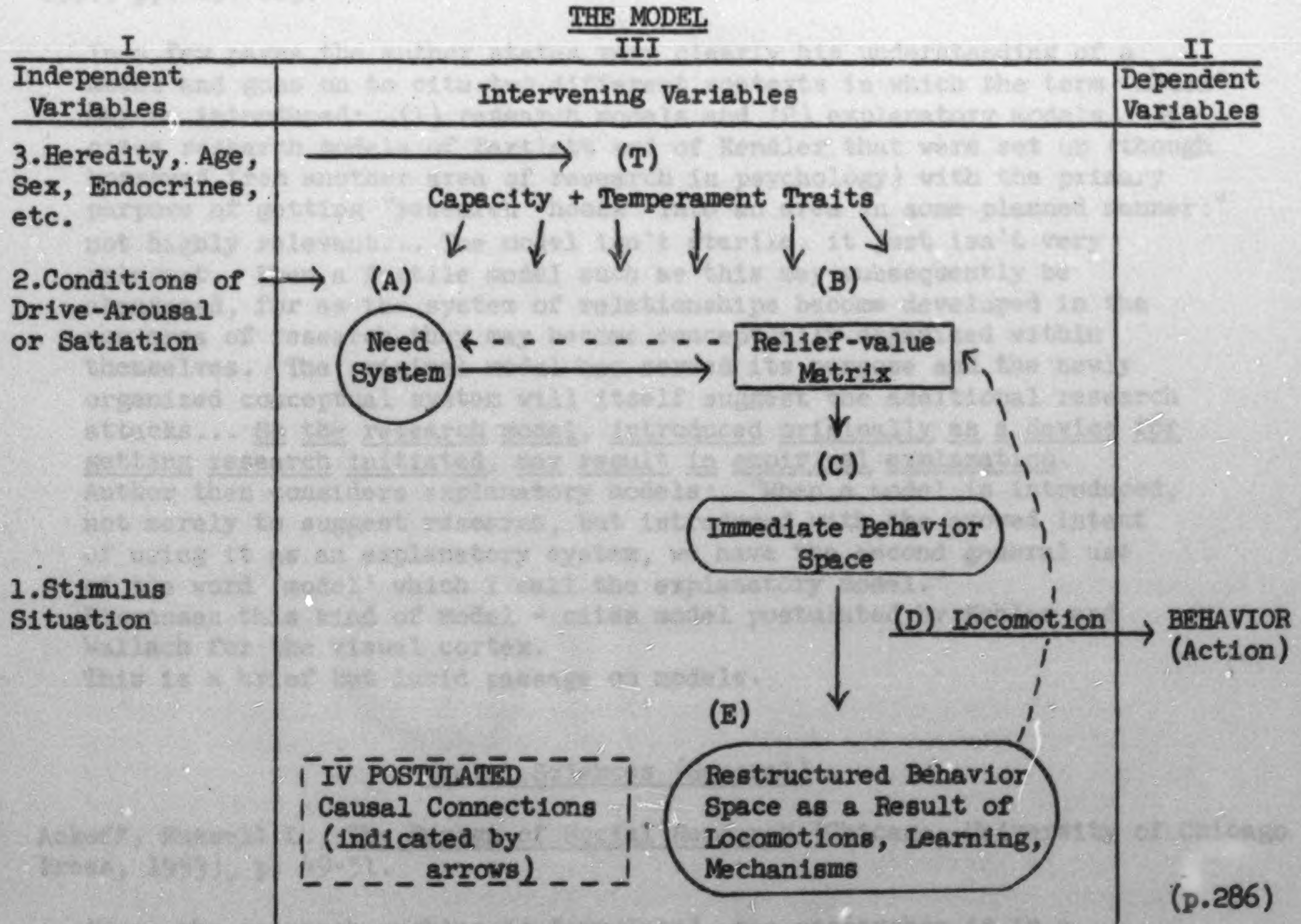
Marx, Melvin H., ed., Psychological Theory (New York, Macmillan, 1951).

Author discusses use of "hypothetical constructs" and then goes on, after recognizing their value, to add:
"Although one must recognize the potential fruitfulness of the use of such models as may be generated by means of hypothetical constructs, it is necessary to exercise considerable caution with regard to the conclusions which are drawn from empirical results obtained in this way. If the model is regarded only as a tool to be used in suggesting empirical investigation and then discarded or modified and retained as a useful guide to experimentation, little danger of unjustified theoretical interpretation is likely to be present. More commonly, however, there is a tendency to regard the empirical results obtained as supporting in some way the theoretical validity of the original model, and the particular hypothetical constructs which have been used. Such conclusions cannot be legitimately drawn..."

Tolman, Edward C., "A Psychological Model," in Parsons, Talcott and Shils, Edward A. eds., "Toward A General Theory of Action (Cambridge, Harvard University Press, 1952) pp. 279-361.

Tolman's contribution to this book is the long Part III of a four part book. He notes three major trends in current theories relative to which ascribed properties are to be found: (1) neurophysiological trend (Hull's stimulus-response ascribing constitutive properties to intervening variables). (2) phenomenological trend (Freud et. al. ascribing introspectively derived characteristics to intervening variables).
(3) "Theories which exhibit the trend toward a suigeneris model invent a set of explanatory structures and processes (hypothetical constructs)

which draw on analogies from whatever other disciplines - mathematics, physics, mechanics, physiology, etc. - as may be deemed useful. Freud's water-reservoir concept of the 'libido', Lewin's 'topological and vector' psychology, and the theory to be presented in the following pages belong primarily in this third category."


THE MODEL

I
III
II
Independent Variables
Intervening Variables
Dependent Variables
3.Heredity, Age, Sex, Endocrines, etc.
(T)
Capacity + Temperament Traits
2.Conditions of Drive-Arousal or Satiation
(A)
(B)
Need System
Relief-value Matrix
(C)
Immediate Behavior Space
1.Stimulus Situation
(D) Locomotion
BEHAVIOR (Action)
(E)
Restructured Behavior Space as a Result of Locomotions, Learning, Mechanisms
IV POSTULATED Causal Connections (indicated by arrows)

(p.286)

...."The theory to be presented here will then be quite frankly one which develops (by analogies drawn from simple physics and mechanics, from Lewin's 'topological and vector' psychology and common experience) a suigeneris model. The model has its own (tentatively) ascribed intervening constitutive structures and processes and its own variety of interconnecting causal functions. The justification for such a model is, of course, wholly pragmatic. Such a model can be defended only in so far as it proves helpful in explaining and making understandable already observed behavior and in so far as it suggests new behaviors to be looked for. And any such model, of course, must be ready to undergo variations and modifications to make it correspond better with new empirical findings... A schema of the model is presented above - and a lengthy consideration of the model ensues under these chapter headings:

1. Introduction
2. The Model
3. Learning and the Psychodynamic Mechanisms
4. Further Problems Connected with the Model
5. Value Standards, Pattern Variables, Social Roles, Personality
6. Summary and Conclusions

Underwood, Benton J., _Psychological Research_ (New York, Appleton-Century-Crofts, 1957) pp. 257-263.

In a few pages the author states very clearly his understanding of a model and goes on to cite two different contexts in which the term "model" may be introduced: (1) research models and (2) explanatory models. He cites research models of Bartlett and of Kendler that were set up (though borrowed from another area of research in psychology) with the primary purpose of getting "research 'hooks' into an area in some planned manner:" not highly relevant... The model isn't sterile, it just isn't very relevant. Even a fertile model such as this may subsequently be abandoned, for as the system of relationships become developed in the new area of research they may become conceptually organized within themselves. The original model has served its purpose and the newly organized conceptual system will itself suggest the additional research attacks... So the research model, introduced originally as a device for getting research initiated, may result in empirical explanation.
Author then considers explanatory models: "When a model is introduced, not merely to suggest research, but introduced with the avowed intent of using it as an explanatory system, we have the second general use of the word 'model' which I call the explanatory model."
Discusses this kind of model - cites model postulated by Kohler and Wallach for the visual cortex.
This is a brief but lucid passage on models.

Social Sciences (General)

Ackoff, Russell L., _The Design of Social Research_ (Chicago, University of Chicago Press, 1953), p. 49-51.

"Once the research problem is formulated, the researcher is in a position to consider how he will solve it. The first step toward obtaining a solution should be the design of an ideal research procedure... The use of an ideal research model (research standard) for the adjustment of actual data is pervasive throughout all the sciences. Consider a familiar physical example: the determination of the acceleration of freely falling bodies. The ideal model for determining such acceleration requires (among other things) a perfect vacuum in which the bodies could fall with complete freedom. Actually, the physicist can never create a perfect vacuum, but he can conduct his experiment so that he can determine how a body would fall if it were in a perfect vacuum. He determines how acceleration is affected by variations in atmospheric pressure. He uses mathematical functions to relate changes in atmospheric pressure to changes in acceleration. Then by extrapolation he determines what would occur in a complete vacuum and thereby infers the acceleration of a freely falling body.

"The idealized research design should consist of specifications of the most efficient conceivable conditions and procedures for conducting the research. This involves asking: (1) What shall I do? (2) To whom? (3) Under what conditions? (4) For what shall I look? More specifically, an idealized formulation of the following aspects of the research is required:

1. X: The subject(s) to be observed...
2. N: The environment(s) to be observed...
3. S: The stimulus (or stimuli) to be observed...
4. R: The response(s) to be observed...

"A research model is a symbolic construct, one in which all the phases of the research are conceptualized. Concepts are needed to formulate the problem and to design ways of solving it. In research, as in other types of behavior, we deal with objects, events, and their properties. In the design of research we have to decide beforehand what objects, events and properties we need to conceptualize. That is, we should decide which concepts are pertinent or relevant to the problem. Once these concepts are identified, they should be defined. Consequently, we need (1) criteria of pertinence to aid in the selection of concepts and (2) guiding principles for constructing scientific definitions..."

The balance of this very good chapter concerns itself with these criteria and principles, to wit: content and form of definitions; fixing or changing variable-values; variables-quantified and qualified; types of quantification and qualification.

Arrow, Kenneth J., "Mathematical Models in the Social Sciences," in Lerner, Daniel and Lasswell, Harold D., eds. The Policy Sciences (Stanford, Stanford University Press, 1951) pp. 129-154.

Author begins article noting limitations of mathematical models, but goes on to state: "It is true, then, that there are certain limitations of mathematical models in the social sciences. Nevertheless, it must be insisted that the advantages are equally apparent and may frequently be worth a certain loss of realism. In the first place, clarity of thought is still a pearl of great price... It is by now a platitude of the scientific method that if theory without empirical evidence is unreliable, empirical inquiry without theoretical background is unfruitful... A second argument, besides that of greater clarity of thought, for the explicit formulation of theories in mathematical terms is the resultant opportunity to tap the great resources of modern theoretical statistics as an aid in empirical verification..."
In Section II some alternative possibilities in the types of mathematical models which are being proposed are discussed in a classificatory way. In Section III, extended examination is given to the "game" theory of social behavior developed by von Neumann and Morgenstern. Section IV considers some other proposed mathematical models for social sciences. Section V discusses recent advances in methodology of empirical work as guided by theoretical models.
p. 153 - "In general, a model in which no two structures generate the same probability distribution of the endogenous variables is said to be identified. In order to make useful statistical inferences, the range of possible structures must be sufficiently restricted by a priori

considerations so that the model is *identified*. A model containing both structures is said to be *unidentified*."

"The method of scientific investigation indicated in the preceding paragraph calls then for intensive *a priori* thinking to formulate a model, followed by the selection of a best-fitting structure from that model by appropriate statistical technique... It is clear that the crucial step is the choice of the model. *If we can say very little on a priori grounds about the nature of the process under investigation, then the resulting model is unidentified, and further progress is stopped*." "...since the statistical methods are best only on the assumption that the model is correct, a serious error in formulating the model may invalidate all further empirical work based on it." This is an intelligible, objective, scholarly paper and should be read.

Beshers, James M., "Models and Theory Construction," *American Sociological Review*, Vol. 22, No. 1, (February, 1957) pp. 32-38.

Gives two views of research: (1) Robert K. Merton - any research project, considered in its entirety, may clarify theory, reformulate theory, initiate new theory, or deflect theory entirely, as well as verify theory. (2) Hans Zetterberg - approaches theory construction by conceiving of research as a verificational process, stressing such properties of theory as formal deductive relationships between postulates and theorems, parsimonius and unambiguous statement of theorems, and the ease with which hypotheses may be empirically tested.

"Mathematical models are constructed by abstracting the properties of some data by measurement, and by expressing these properties in a set of symbolic statements that include the logical relationships that hold for the entire set of statements. Any mathematical statement may be regarded as a model by identifying the symbols of the mathematical statement with some data. However, it is convenient to restrict the designation 'mathematical model' to the body of statements that constitute the axioms of a mathematical system, however small...

"In sociology the concept corresponding to model is the construct, or ideal-type, e.g., the Protestant ethic. The construct is an abstract statement of properties of data, but it is not expressed in symbolic form, nor is the process of abstraction as explicit as measurement. Constructs can usually be found independent of developed theories, but those constructs contained within a general theoretical system are analagous to mathematical models (as discussed above). Perhaps the set of assumptions, or axioms, of a sociological theory could be referred to as a model in the same sense as a mathematical model, e.g., system model-system theory.

"...Within a particular theoretical framework the hypotheses are subject to tests; statements in the model are not directly subject to test. The same statements, which may be part of the model in one theory, may under some circumstances be hypotheses in another theory."

"In any research project, a model is a set of assumptions, or postulates, not being directly tested. Some efforts may be made to test the model during the research project, but the main objective of the research is to test hypotheses developed from the model.

"...Within a specific research project, a model initially may be a loose verbal statement, but in the end may be refined into a precise mathematical statement. Similarly, as a new area for research is opened up, models are generated by a series of exploratory research projects that (1) identify important factors, (2) assess the relative importance of these factors, and (3) state the relationships among these factors. These models would be made up of the assumptions of the research project, loosely phrased as they might be.

"This discussion has identified models as the assumptions of an axiomatic theory and as the assumptions of a research project.

"In general, models are constructed with two criteria in mind. First, they should be convenient: they should facilitate the processes of research design, hypothesis formation, and data analysis. Second, they should be plausible: they should be congruent with the data they are supposed to represent."

There are two general types of mathematical model - the causal model and the statistical model. A causal model states the lawful relationship between events. A statistical model states the relative frequency of occurrence of certain events based on the modern theory of probability.

Blackwell, David and Girshick, M. A. Theory of Games and Statistical Decisions (New York, Wiley, 1954).

A further extension of von Neumann-Morgenstern's work, and even more difficult.

Brodbeck, May, "Models, Meaning and Theories," in Gross, Llewellyn, ed., Symposium on Sociological Theory (Evanston, Ill., Row Peterson, 1959) pp. 373-403.

p. 379 - Two theories whose laws have the same form are isomorphic or structuraly similar to each other. If the laws of one theory have the same form as the laws of another theory, then one may be said to be a model for the other. This definition of "model" in terms of an ismorphism between theories at least provides one unambiguous meaning for that term. That it is not consistently used in this way by scientists is, of course, one reason why the notion requires clarification.

Posits the possible same form for two theories to ascertain if rumors spread like disease.

Lists "speculative 'models' or guesses about isomorphisms" in social science: society is like an organism, or like a plant; or society is compared to the growth and physiology of a man; the evolutionary theory is another favorite model, or, the human brain is compared to an electronic computer. Servomechanisms are evoked models for learning and purposive behavior.

p. 380 - Author notes that "...not only must the terms of the two areas correspond, but the connections among these concepts must also be preserved, if the model is to be of any use."

Isomorphism of the laws of one theory with those of another unequivocally defines the term, "model."

The first unnecessary use of "Model" is as a synonym for "theory." Lists four kinds of theories that are often erroneously called models. Third prevalent use of the term model - either in "mathematical model" which may mean any quantified theory or which may mean any arithmetical structure - this is called an arithmetical representation - that is, whenever the laws of an empirical theory have the same form as a set of purely arithmetical truths. She discusses four: analytical geometry, probability theory, measurement, and theory of games.

p. 391 - Formulizations of theories are also sometimes called "mathematical models."

"Mathematical model" then has three meanings:
1) Quantified empirical theory
2) Any arithmetical representation of an empirical theory
3) The formalization of a theory.

Her basic notion of model is as a set of statements isomorphic to another set of statements. (also ideal of complete and incomplete isomorphism)

Devotes a section to Models in Physics where the assumptions of a mechanical model (the science of mechanics serving as a "model" for thermodynamics in kinetic theory of heat) transfer the laws of an already independently confirmed theory to the behavior of invisible entities..."

Bross, Irwin D. J., Design for Decision (New York, Macmillan, 1953) pp. 161-182.

Bross in his chapter on Models, discusses various kinds of models:
1) Physical - model airplane for example
2) Abstract - solar model of the planetarium
3) Symbolic - the physical properties of the physical model are replaced by mathematical concepts to yield an astronomer's model.
4) Mathematical - model is constructed from symbolic language

Mention is made of three landmarks in model-making: Isaac Newton's, Einstein's relativity model, and quantum model. "In biology the evolutionary model of Charles Darwin (a verbal model) has been developed into a mathematical model by R. A. Fisher and Sewell Wright." Also mentioned is Harvey's model of the circulatory system, and Wiener's use of a mathematical model associated with the operation of the brain in Cybernetics. Advantages of model making are considered - a big advantage of a model is that it provides a frame of reference for consideration of the problem. Some of the greatest scientific advances have been

produced by failure of a model. Einstein's work was the outgrowth of the Michelson-Morley experiment in which the aether model led to unsuccessful prediction.
"The standard for comparing models is utility, i.e., successful prediction."
Considers acceptance of wave and photon models in physics for light.
Considers the role of the model, a model for data and some statistical models.
Three illustrations are presented.

George, F. H., "Models and Theories in Social Psychology," in Gross, Llewellyn, ed. Symposium on Sociological Theory (Evanston, Ill., Row, Peterson, 1959). pp. 311-347.

p. 335 - "It is certainly generally accepted that we can proceed from a set of statements of direct observation to generalizations, by inductive inference, and from the generalizations back to the testable particulars by deduction. This is the theory; the model is in essence the skeletal logical structure of this theory. There is thus clearly the closest relation between theory and model."
He also refers to Braithwaite's zippers: "His (Braithwaite) view is that there is a sort of parallel between the development of scientific theories from observation statements on one hand and the reconstruction of empirical data from a model on the other. These are two parallel zip fasteners as it were, the theoretical zipper being tied to observations at the bottom, and the model zipper being tied to observations at the top..."

p. 337 - adds to utility of a theory the note of "plasticity in allowing precise rules to be derived from it whenever the need arises."

p. 313 - "...but here we make the essential distinction...between a model for a theory and the theory itself. The model, it should be noticed, will be explained in the theory; to speak metaphorically, a model is a skeleton and the theory is the complete organism, including the flesh. The theory is to be couched in the natural or symbolic language that is used for descriptive purposes by the particular investigators, and we shall call this the 'theory language'."
"...what needs to be developed is a model with a theory that has a controlled vagueness - that of the surplus meaning of the theoretical terms. This lack of specificity, this possibility of many interpretations of the same model, is necessary to the fruitfulness of science.

p. 314 - "If we merely use descriptive language for the generalizations (from observations) we must be prepared to show the nature of the underlying structural model, since a description of empirical facts is really a description of complex structural relations (a model). This process of showing the structure of the model is called the formalizing of the theory."

p. 315 - "The model we have in mind (the one to be discussed) is that of a Finite Automaton, which for practical purposes is an idealized organism." He uses logical nets for his theory construction - he describes their composition and gives a diagram - extends model so it is capable of use in developing a theory of (p. 323) perception where he notes: "The theory for the above model for perception is, strictly speaking, the interpretation placed on the model. In fact, the theory was formulated first and the model provided after." Model accommodates a theory of motivation, emotion, memory.

Hyman, Herbert, Survey Design and Analysis (Glencoe, Ill., Free Press, 1955).

In Chapter VI on "The Introduction of Additional Variables and the Problem of Spuriousness" the author writes on the "controlled experiment as a model":
"The scientific model for the study of cause-and-effect relationships is the controlled experiment, in which responses of an experimental group, exposed to the crucial stimulus, are compared with those of an equivalent control group, from which the stimulus has been withheld." Diagrammatically, the controlled experiment can be represented by the following scheme:

	Experimental Group	Control Group
Time 1	X_1	Y_1
	Exposure to Stimulus	No Exposure to Stimulus
Time 2	X_2	Y_2

Uses example of TV program in political campaign.

$$\text{Effect of TV} = (X_2 - Y_2)$$

Then author goes into the problem and methods of control in a survey.

Lazarfeld, Paul F., ed., Mathematical Thinking in the Social Sciences (Glencoe, Ill., The Free Press, 1954).

Introduction allows: "A hundred years ago the task seemed to be to make sweeping guesses as to the future development of society. Fifty years ago the interest focussed on basic concepts which would properly classify the crucial social phenomena. Today the trend is toward singling out the basic variables from which all specific concepts and interrelationships can be derived. Even those who do not believe in any early use of mathematics try to utilize some rudiments of formalization, in order to clarify their underlying assumptions, and to derive specific findings from more general models."

In this volume several various simple and complex models are considered. In the first paper, written by T. W. Anderson of Columbia, a very simple model is set up to explain a change in attitude. The author endeavors to keep the model simple by setting up a model which explains changes in a given attitude only in terms of the previous history of change in this one attitude; other factors are neglected.

The book contains eight fine articles all concerned with models using mathematical formulations for the interpretation of specific behavior.

Meadows, Paul, "Models, Systems and Science," American Sociological Review, Vol. 22, No. 1 (February, 1957) pp. 3-9.

Excellent article - short but must be read in its entirety.

Miller, James G., "Toward a General Theory for the Behavioral Sciences," American Psychologist, Vol. 10, (September, 1955) pp. 513-531.

This is a very lengthy, interesting paper originally given at Arden House at the Conference on the Evolution of Behavior, April 5, 1955. The paper sets up a general behavior systems theory that concludes with 19 propositions, spelled out in considerable detail.
Re: Models:-
p. 522 - "Much of the criticism of analogy in behavioral science has been directed particularly at formal models like the ones we expect to incorporate into general behavior systems theory. One such argument is that models simply describe what was already known and do not reveal anything new. Certainly this is not true of all models as for instance those concerning the learning process, which have led to the discovery of many new facts. This criticism is apt only when applied to poor models." Model builders must be intimately acquainted with social or behavioral phenomena... If appropriate parameters are chosen, the model can be progressively modified to approximate more and more closely to the real system. If model builders are sufficiently informed about the phenomena that they select the proper dimension, they can throw much light on the nature of the process they are studying.
"It is sometimes said that, because of the many variables it is more difficult to use formal models in the behavioral than in other sciences. But models have been used to study complex, multi-variant problems in the physical and biological sciences."
"Another criticism is that models are always in error, never being precisely correct. It is hard to say how correct a model must be to be scientifically useful. The answer is that there is probably no correct model, but the goal is to find one which will explain the largest number of known facts. As further empirical data are collected and more thinking goes on, models usually are rejected and more satisfactory ones substituted. The purpose of the scientific process is to improve the goodness of fit of the model to the empirical data, that is, its predictive power...Actually models can describe complete phenomena like the social structure of a community more economically, precisely and fully than most verbal descriptions. In addition, they can suggest new variables or relationships to investigate. From models explicit predictions can be made, whereas in the past social scientists have typically made very loose predictions if they have made them at all. Furthermore, it is possible to calculate the error of the outcome of a prediction, which has not been a common social science method."

This excellent article goes into an adequate statement of electronic models (p. 523) with a large diagram of same on p. 524 - and then the 19 propositions are given.

Rapoport, Anatol, "Uses and Limitations of Mathematical Models in Social Science," in Gross, Llewellyn, ed., *Symposium on Sociological Theory* (Evanston, Ill., Row, Peterson, 1959) pp. 348-372.

In one sense, this article is an apology for the plight of the social scientist in constructing theory. The first 5 or 6 pages compares (or contrasts) the advantages of the physical scientist in working with measurables over the immeasurables of the social scientist - the author would enlist the aid of the mathematicians and also increase the social scientists' appreciation of the contribution that the mathematician can make to social science theory construction. Speaking of a social science the author states: (p. 353) "Difficult as the construction of such a science is in the absence of a toe hold (such as was provided for the physical scientist by the regularities in the notions of heavenly bodies), attempts in that direction have been made. The method of constructing a mathematicized social science is embodied in the concept of the so-called mathematical model.

"A word is in order on the way the mathematician uses the term 'model,' since this usage departs from that prevalent in other disciplines. Outside of mathematicized sciences, the term 'model' often refers to an analogical explanation. To take an example, Marxist sociological theory explains revolutions as instances of quantitative changes suddenly becoming 'qualitative' and cites as an analogue of such phenomena the change of state of water to steam upon being heated. With even greater vividness, a revolution may be likened to an explosion. Explosion is supposed to be a 'model' for revolution. Psychoanalysts postulate principles of 'conservation of psychic energy' embodied in the construction of the so-called 'hydraulic model' of psychodynamics, in which 'forces' are supposed to be exerted by the various parts of the 'psyche' upon the 'border of consciousness.' These are analogical or metaphorical models. Their explanatory value, if any, is in the appeal to see in a seeming similarity of two phenomena the explanation of the unfamiliar one in terms of supposed understanding of the familiar one.

"With such constructs, mathematical models have only one thing in common- the property of 'as-if-ness.' Mathematical models also rest on fictions, on appeals to look at events *as if* the underlying 'causes' had a certain structural analogy to the model proposed. But there the similarity ends. The mathematical model invariably leads to *specific* relations among *specific* variables. In principle, these relationships are verifiable by experiment or observation. If they are so verified, the assumptions underlying the model are *to a certain extent* corroborated.

"The test of the mathematical model, then, is in the specific predictions, and *the simpler* the underlying assumptions, the more valuable the model. The Newtonian Law of Gravitation is a superb example of a mathematical model."

(Note the use of the words *theory* and *model* somewhat interchangeably) Author considers Rashevsky's theory of mass behavior; a statistical theory of social structure and the theory of games under some new approaches to economic behavior.

Simon, Herbert A., Models of Man (New York, John Wiley and Sons, 1957).

A collection of 16 articles by Simon which have appeared in 13 journals, representing statistics and all the social sciences save anthropology. Most of the essays contain a number and variety of mathematical formulations of social sciences. The author notes the essays are intelligible to anyone who has had a good introductory course in calculus. Countless models are used in the essays, ranging from "A Behavioral Model of Rational Choice" to a "Deviate-Member Model" in the essay "Group Pressure on Deviate-Members."

Vail, S. V., A Stochastic Model of Utilities. Unpublished manuscript No. 24. University of Michigan, Seminar on the Applications of Mathematics to the Social Sciences, April 23, 1953.

Social Work

Hearn, Gordon, Theory Building in Social Work (Toronto, Canada, University of Toronto Press, 1958).

A book essentially about theory building, suggesting a particular way the development of theory may refine any service profession's mode of practice. In Chapter II, "Theory Building," terms are clarified. A model is defined as the symbolic representation of a perceptual phenomenon. He notes models vary in two ways, namely, in their level of abstractions - pictorial models to mathematical models, and in terms of the metaphor they employ - organism, machine or field.

Hearn further distinguishes the analogue. An analogue is that which is assumed to be similar in nature and function to some other thing. It is an observable example of the metaphor upon which a particular model is based. The book contains an excellent description of theory building.

Statistics

Chernoff, Herman and Moses, Lincoln E., Elementary Decision Theory (New York, Wiley, 1959).

In an extensive chapter on models, the authors in this book on statistics state: "We shall regard a model as a useful convenient simplified representation of the essentially important aspects of a real object or situation. In this sense, the architect's model, the floor plan, and the builder's list of specifications are all models of the house. Not one of these is a perfect description, but each is adequate for its special use."

"In the application of statistical ideas to real problems, it is necessary to represent a problem in a simplified form or model, to solve the corresponding model by the appropriate computations, and to convert the solution into the action it represents... How do we know when a model is adequate? Often there are clear-cut signs when the model is inadequate. Two such signs are ridiculous answers and failure of the solution. In this chapter we shall discuss models of aspects of decision making. The objective is to give some ideas of effective model building..." The following models are given:

1) Models of Probability and Utility
2) " of the Set of Available Actions
3) " of Sets of Possible States of Nature
4) " of Regret Functions
5) " of Experiments
6) " of the Set of Available Strategies
7) " for the Problems of Testing and Estimation.

Coombs, C. H., "Mathematical Models in Psychological Scaling," Journal of the American Statistical Association, Vol. 46, No. 256 (December, 1951), pp. 480-489.

This paper stresses the importance to social science and psychology of "the implication of mathematical and statistical theory applicable to numbers which are not elements of fields."
The author distinguishes between measurement and scaling. He considers the ordered metric scale, the partially ordered scale, and the dilemma of the social scientist when he must select a scale of measurement for expressing the data. "In selecting a scale of measurement he is in effect making the axioms of that type of scale his assumptions or postulates which are then imposed on the data." The selection of a strong axiom system, like a ratio or interval scale, will give him powerful mathematical and statistical tools, but he will have more error variance, fit less of his data, etc. A weaker axiom system will give less error variance, more data will fit etc. but he will not have elaborate statistical models for testing hypotheses yet he will get more complex answers.

He recognizes this dilemma of the social scientist and closes with a quote from Frank Knight, an economist, who describes the prevailing measurement procedures in the social sciences with the dictum, "If you can't measure, measure anyhow."

McCarthy, Philip J., Introduction to Statistical Reasoning (New York, McGraw-Hill, 1957).

In this basic statistics text book several models are given:

1) Binomial probability model.
2) Linear-regression model.
3) Simple random sampling model.

Michael, William G., "Development of Statistical Methods Especially Useful in Test Construction and Evaluation," in "Educational and Psychological Testing," Review of Educational Research, Vol. 29, No. 1 (February, 1959), pp. 106-129.

This article reviews published papers in the field since the 1956 issue of the Review's "Educational and Psychological Testing." A section on development of statistical models for the analysis of test-taking behavior is included. However, this "overview" review is so cursory it will actually be necessary to check published papers reviewed in their original statement to be of any value to us.

Zelditch, Jr., Morris, A Basic Course in Sociological Statistics (New York, Holt, 1959).

In the preface to this "most elementary of all elementary texts on statistics," it is stated: "The central problem of the application of statistics is in the relation of the model to practical circumstance. By 'model' we mean the definitions and assumptions which the mathematicians make in order to create the statistical methods we use. It is from these definitions and assumptions that he is able to derive the principles of practical procedure, the formulas, the tables, etc. that make up the statistician's working tools. The model is prerequisite to precise conclusions."